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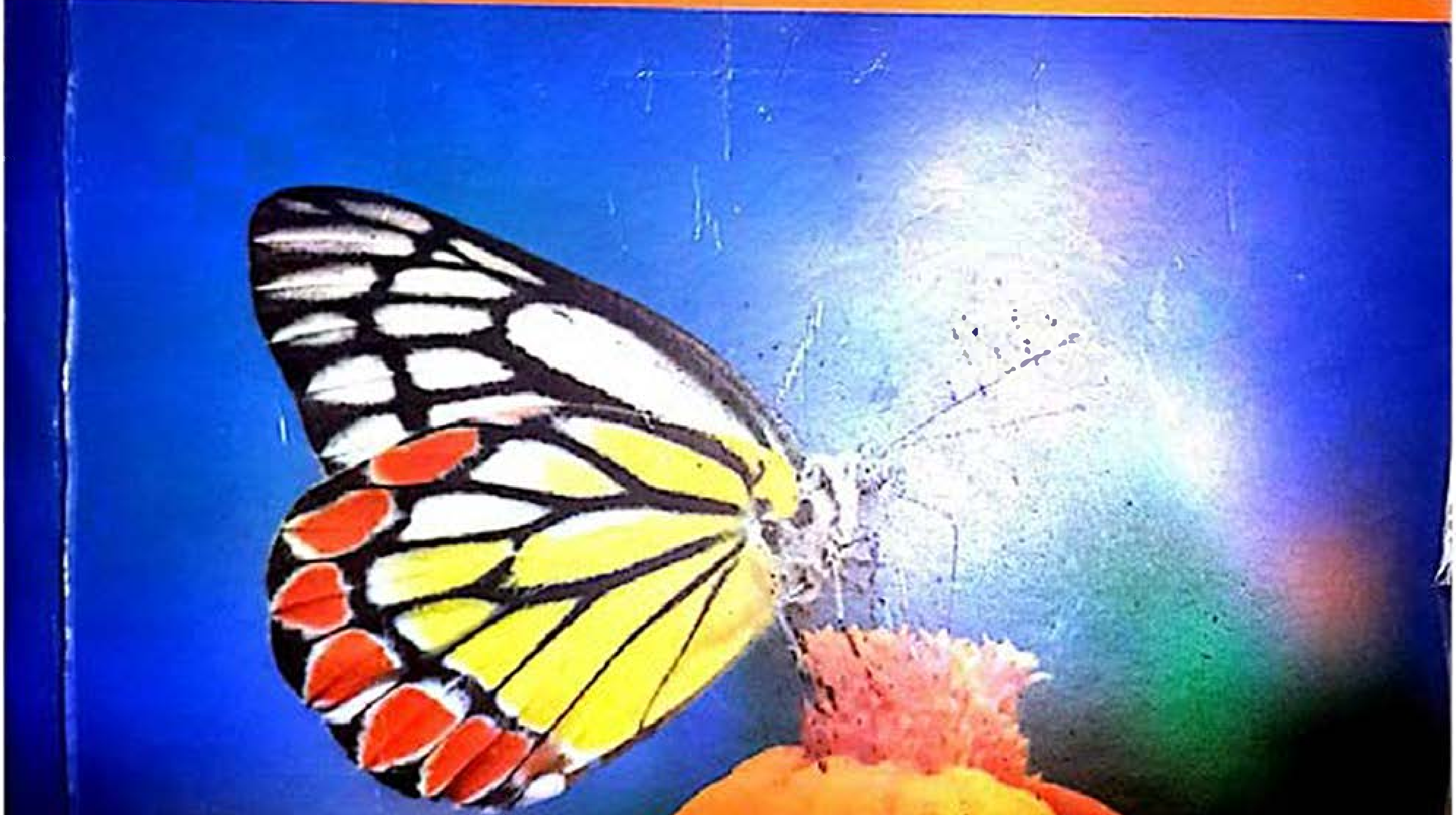
Lucent's

General Science



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* * *

SCIENCE

Science : The word science comes from the Latin word *Scientia* which implies *Knowledge*. The Science as a subject has come to mean the systematic, consistent and excellent study of the physical world including everything that can be seen, observed or detected in nature by the man and society and the knowledge that grows out of such study. Usually the science is characterized by the methodologies and approaches of the hypothesises, postulates, assumptions, theories and laws based upon experimental observations and mathematical conclusions.

The science is broadly categorized into two groups— Natural science and Social science. Natural science deals with nature or physical world while social science deals with the subjects like sociology, economics, political science, human geography etc. Here in this book we are concerned about natural science only. Natural science is broadly divided into :

1. Physical science (studies concerned with non-living matter).
2. Life science or Biological science (studies concerned with living matter).

On the macro-level physical science consists of Physics and Chemistry while life science (Biology) consists of Botany and Zoology.

The contents of the Astronomy and Computer (especially their elementary and fundamental concepts) are today also assumed (considered) to be the part of the conventional science.

At present research and development activities in various branches of natural science like astrophysics, geophysics, biophysics, biochemistry, genetics, virology, evolution and ecology etc. are going on in earnest.

01. Physics

Physics : Physics is associated with those aspects of nature which can be understood in the most fundamental way in terms of the elementary principles and laws. In other words Physics is that branch of physical science in which matter and energy mutually interact with each other.

Physics is usually studied in the following groups—

I. General Physics (Mechanics)

1. Quantity and Measurement

Quantity : Anything, which is expressed in number or whose representation is totally numerical is called quantity.

Example : Population, Ages of men or women, weights of objects etc.

Physical quantity : Quantities expressed in terms of laws of physics are called physical quantities.

Example : Mass of an object, length, force, speed, distance, displacement, momentum, electric current etc. These physical quantities are of two types (i) scalars (ii) vectors.

(i) Scalars : Those physical quantities which have magnitude only and whose direction is not taken into the consideration are called *scalars*.

Example : Mass, temperature, density, volume, electric current, work etc.

(ii) Vectors : Those physical quantities which have both magnitude and direction and which are represented by the directed line segment (→) obeying the triangle law of vectors or parallelogram law of vectors are called *vectors*.

Example : Displacement, linear momentum, angular velocity, torque, magnetic field intensity, electric displacement, current density etc.

A physical quantity which has both magnitude and direction but which doesn't obey vector laws of addition or subtraction is not a vector quantity, like electric current, pressure, work etc. Also there are certain physical quantities which are used both as scalar and vector. Simply *area* is treated as a scalar, while normal area is treated as a vector.

Units of Measurement : To measure any quantity, a definite and a substantial amount of that quantity, is assumed to be standard which is called *unit* of the quantity and when any given quantity is measured in the terms of this unit, the process is called *measurement*. There are usually two types of units—

(i) Fundamental Units (ii) Derived Units

(i) Fundamental Units : If a physical quantity is expressed in terms of units which are used as standards and these standards are independent of each other, then these units are called *Fundamental*

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During the early stage of research and development the units of Length, Mass and Time were assumed to be Fundamental. But later the units of Electric Current, Temperature, Luminous Intensity and the amount of substance were added and thus at present there are seven Fundamental Units.

Derived Units : If a physical quantity is expressed in terms of two or more fundamental units then these units are called *Derived Units.* These units have no independent existence like fundamental units. The unit of Force, Momentum, Work, Potential Energy, Density etc. are Derived Units.

System of Units

Usually physical quantities are measured in four systems of units.

(i) CGS System (Centimeter/Gram/Second System) : In this system of units Length, Mass and Time are measured in Centimeter, Gram and Second respectively. CGS system is also called *Metric or French System of Units.*

(ii) FPS System (Foot/Pound/Second System) : In this system of units Length, Mass and Time are measured in Foot, Pound and Second. FPS system is also called British System of Units.

(iii) MKS System (Meter/Kilogram/Second System) : In this system of units Length, Mass and Time are measured in Meter, Kilogram and Second.

(iv) SI System (International System of Units) : In the International Conference of Weights and Measures held at Geneva in 1960 the SI System of Units was adopted and accepted on the basis of a comprehensive consensus. In fact SI system is extended and modified form of the MKS System.

There are *Seven Fundamental Units* and *two Supplementary Units* in SI system.

Seven Fundamental Units of SI System :

(i) Length : In SI System Length is measured in *meter* and is defined as—

Total distance travelled by light in vacuum in 1/299792458 sec is called 1 *meter.*

(ii) Mass : In SI system Mass is measured in *Kilogram* and is defined as—

The amount of the mass of a cylindrical alloy of Platinum-Iridium kept at International Bureau of Weight and Measure at Severis in France is called 1 *kilogram.*

(iii) Time : In SI system Time is measured in *second* and it is defined as—

In the transition of two hyper fine levels of energy in the ground state of an atom of Cesium–133 by means of radiation between an interval of 9192631770 time-periods is called 1 second.

Einstein in his special Theory of Relativity used Time as fourth coordinate in Space-Time coordinate system.

(iv) Electric current : In SI system Electric current is measured in *Ampere* and is defined as—

If two long parallel wires (coils) are kept 1 meter apart through which an electric current is passed in such a way that it produces a magnetic force of 2×10^{-7} N, then the magnitude of the electric current is called 1 *Ampere.*

(v) Temperature : In SI system Temperature is measured in *Kelvin* and is defined as—

Three phases of water-solid (ice), liquid and vapour-coexist at 273.16 K which is called triple point of water and this temperature is called critical temperature and its 1/273.16th part is called 1 *kelvin.*

(vi) Luminous Intensity : In SI system luminous intensity is measured in *Candela* which is defined as—

If any monochromatic source of light produces a frequency of 540×10^{12}Hz in a definite direction and if its intensity is 1/683 watt/steradian, then is Luminous Intensity is of 1 *Candela.* If 1 Joule energy is emitted in 1 sec within any solid angle, then it is called 1 watt/steradian.

(vii) Amount of Substance : In SI system Amount of Substance is measured in Mole which is defined as—

If the number of molecules, atoms or ions present in any substance or element is 6.023×10^{23}, then the required amount of the substance or element is called 1 mole.

If this number of molecules, atoms or ions in any substance or element is 6.023×10^{23}, then it is also called *Avogadro's Number.* Thus *Avogadro's Number* = 6.023×10^{23}.

or, 1 mole = Avogadro's number

Supplementary Units of SI system

There are two Supplementary Units in SI system.

(i) Radian : The plane angle made by any arc of a circle of equal radius is called 1 radian. All plane angles are measured in *radian.*

(ii) Steradian : The solid angle made on the centre of a sphere by the area formed as a square on the surface of the sphere where the side of the square is equal to the radius of the sphere is called 1 steradian. All the solid angles are measured in *steradian.*

Fundamental Units

Physical Quantity	S.I. Units	Symbol
Length	Meter	m
Mass	Kilogram	kg
Time	Second	s
Electric current	Ampere	A
Temperature	Kelvin	θ or K
Luminous Intensity	Candela	cd
Amount of Substance	Mole	mol

Supplementary Units

Physical Quantity	S.I. Units	Symbol
Plane Angles	Radian	rad
Solid Angles	Steradian	Sr

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Velocity
Force
✓Linear Mo
Pressure
Work or E
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1 LY
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Some Important Derived Units

Physical Quantity	Definition of Quantity	S.I. Units
Area	Length Square	m^2
Volume	Length Cube	m^3
Density	Mass per unit Volume	kgm^{-3}
Velocity	Displacement per unit Time	ms^{-1}
Force	Mass × Acceleration	$kg\ ms^{-2}$ *or* Newton
Linear Momentum	Mass × Velocity	$kg.\ ms^{-1}$
Pressure	Force per unit Area	Nm^{-2} or Pascal
Work or Energy	Force × displacement	N-m or Joule
Magnetic Field Intensity	$\dfrac{\text{Force}}{\text{electric current} \times \text{displacement}}$	N-amp^{-1} m^{-1} or Tesla or weber/m^2

Various Exponents of 10

Exponent of 10	Prefix	Symbol	Exponent of 10	Prefix	Symbol
10^{18}	Exa	E	10^{-1}	Deci	d
10^{15}	Peta	P	10^{-2}	Centi	c
10^{12}	Tera	T	10^{-3}	Milli	m
10^{9}	Giga	G	10^{-6}	Micro	μ
10^{6}	Mega	M	10^{-9}	Nano	n
10^{3}	Kilo	k	10^{-12}	Pico	p
10^{2}	Hecto	h	10^{-15}	Femto/Fermi	f
10^{1}	Deca	da	10^{-18}	Atto	a

Units for Astronomical distance :

(i) Astronomical Unit (A.U.) : It is a *unit of distance*. It is mean distance between Sun and Earth.

1 A. U. = 1.495×10^{11} meter.

(ii) Light Year : It is also a *unit of distance* and it is distance travelled by light in vacuum in one year.

1 Light Year = 9.46×10^{15} meters.

(iii) Par sec (Parallax Second) **:** It is the *largest unit of distance* among all the astronomical units of distance and 1 Par sec = 3.08×10^{16} meters.

Units of Length or distance

1 km	= 1000 m
1 mile	= 1.60934 km
1 NM	= 1.852 km
1 AU	= 1.495×10^{11} m
1 LY	= 9.46×10^{15} m
	= 48612 A.U.
1 Par sec	= 3.08×10^{16} m
	= 3.26 ly

Units of Mass

1 Ounce-OZ	= 28.35 gm
1 pound-lb	= 16 OZ
	= 453.52 gm
1 kg	= 2.205 lb
	= 1000 gm
1 Quintal	= 100 kg
1 Metric ton	= 1000 kg

Units of Time

1 minute	= 60 sec
1 hour	= 60 min
	= 3600 sec
1 day	= 24 hours
1 week	= 7 days
1 lunar month	= 28 days
	= 4 weeks
1 solar month	= 30 or 31 days
	= 28 or 29 days (Feb)
1 year	= 13 lunar month 1 day
	= 12 solar month
	= 365 days
1 leap year	= 366 days

Units of Area

1 acre	= 4840 sq. yard
	= 43560 sq. feet
	= 4046.94 sq. meter
1 hectare	= 2.5 acre
1 sq. km	= 100 hectare
1 sq. mile	= 2.6 sq. km
	= 256 hectare
	= 640 acre

Units of volume

1 litre	= 1000 cubic cm (cc)
	= 0.2642 gallon
1 gallon	= 3.785 lit.

Dimensions of Physical Quantities

In Physics Length, Mass, Time, Temperature, Electric Current etc. which are symbolically represented by L, M, T, O, A have vital and significant roles. All physical quantities are expressed in terms of power (exponents) of these symbols called *dimension*.

Example : $\text{Area} = L \times L = L^2$, $\quad \text{Density} = \dfrac{\text{Mass}}{\text{Volume}} = \dfrac{M}{L^3} = ML^{-3}$

$$\text{Force} = \text{mass} \times \text{acceleration} = M \times LT^{-2} = MLT^{-2}$$

$$\text{Magnetic Field Intensity} = \frac{\text{Force}}{\text{current} \times \text{displacement}} = \frac{MLT^{-2}}{A \times L} = MA^{-1}T^{-2}$$

2. Motion and Force

Rest and Motion : If the position of a body changes with time, then the body is said to be in *motion* but if the position of the body does not change with time then it is said to be in *rest*.

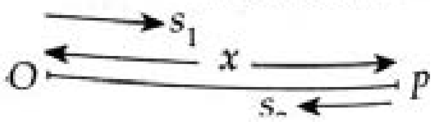
Distance : The total length of the path travelled by a body in any given time interval is called *distance*. In other words, distance is total length between the initial and final positions of the body in a particular interval of time without taking into account the direction of the motion. This is a scalar quantity and is never –ve, and its S.I. unit is meter.

Displacement : The least distance executed by a body between the initial and final points (position) of a straight line motion in a definite direction is called *displacement* and it is a vector quantity. The displacement may be +ve, –ve or zero, and its S.I. unit is meter.

Velocity : If a body going in a definite (fixed) direction during its straight line motion changes its position in unit time, then this is called the velocity of the body. Thus *velocity* of a body is the rate of change of its position in a fixed direction. Velocity is a vector quantity and its S.I. unit is ms^{-1} and its value may be +ve, –ve or zero.

Average Speed : Average speed is defined as total distance travelled by a body upon total time elapsed. Thus

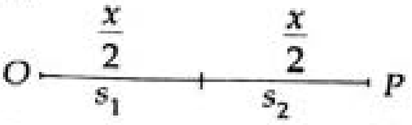
$$\text{Average Speed} = \frac{\text{Total distance travelled}}{\text{Total time elapsed}}$$



→ 1000ml = 1000cc

If a body travels x distance with speed s_1 and comes back with speed s_2 and the body takes t_1 and t_2 times respectively then

$$\text{Average Speed} = \frac{x + x}{t_1 + t_2} = \frac{2x}{\frac{x}{s_1} + \frac{x}{s_2}} = \frac{2 s_1 s_2}{s_1 + s_2}$$



If a body covers half of the distance with speed s_1 and another half with speed s_2 then the average speed for the distance OP of the body $= \frac{\frac{x}{2} + \frac{x}{2}}{t_1 + t_2}$

$$\Rightarrow \quad \text{Average Speed} = \frac{s_1 t_1 + s_2 t_2}{t_1 + t_2}$$

$$= \frac{(s_1 + s_2)t}{2t} = \frac{s_1 + s_2}{2} \qquad [t_1 = t_2 = \text{t (say)}]$$

Speed : Total distance covered by a body between the initial and final points of a straight line motion without any consideration of direction in unit time is called speed of the body. Thus speed of a body is *the rate of change of its position.* It is a scalar quantity and its S.I. unit is ms^{-1}.

Average Velocity : The average velocity of a body is defined as total displacement of the body upon total elapsed time.

$$\text{Thus Average Velocity} = \frac{\text{Total displacement}}{\text{Total time}}$$

Instantaneous Velocity : If a body moves in such a way that its average velocity measured for a number of different time intervals does not turn out to be constant and the body is said to be moving with variable velocity, then the velocity of the body at any given instant of time is called instantaneous velocity and it is expressed as

$$= \vec{v} = \lim_{\Delta t \to 0} \frac{\Delta \vec{r}}{\Delta t}$$

Acceleration : The *rate of change of velocity* of the body is called *acceleration* of the body. If the velocity changes uniformly at equal interval of time, then acceleration is said to be *uniform acceleration.* If the velocity of a body increases with time then the body is said to be *accelerated* and conversely if velocity decreases with time then the body is said to be *retarded* or *deaccelerated.* Acceleration is a vector quantity and its S.I. unit is ms^{-2}

Mathematically, acceleration $= \frac{d\vec{v}}{dt}$ and if $\vec{v} = \frac{d\vec{x}}{dt}$

then acceleration $= \frac{d\vec{v}}{dt} = \frac{d}{dt}\left(\frac{d\vec{x}}{dt}\right) = \frac{d^2\vec{x}}{dt^2}$

If any body moves with a constant velocity then

acceleration $= \frac{d\vec{v}}{dt} = 0$ (as $\vec{v}$ is constant)

Thus in uniform motion acceleration does not exist. If the body is in *rest* then obviously *velocity does not exist* and thus *no acceleration* exists.

Relative Velocity : The relative velocity of one body with respect to that of another is the rate of change of displacement of one body relative to that of another and vice-versa.

If $\vec{v}_A$ and $\vec{v}_B$ are the constant velocities of two bodies A and B, then $\vec{v}_{BA}$ is the symbolical representation of the relative velocity of B with respect to A and the relative velocity of A with respect to B is expressed as $\vec{v}_{AB}$.

Mathematically; these are expressed as; $\vec{v}_{BA} = \vec{v}_B - \vec{v}_A$ and $\vec{v}_{AB} = \vec{v}_A - \vec{v}_B$

Equations of Motion : If a body describes a straight line motion with an initial velocity u in time t, covers a distance s with a uniform acceleration a and finally acquires velocity v then, by applying the fundamental principles of *Classical Newtonian Mechanics*, Galileo derived the following equations which are called Kinematical Equations of Motion.

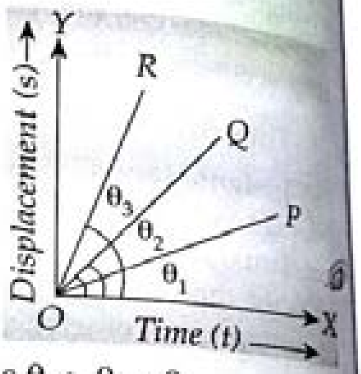
Equations of motion are : (i) $v = u + at$ (ii) $s = ut + \frac{1}{2}at^2$

(iii) $v^2 = u^2 + 2as$ (iv) $S_n = u + \frac{1}{2}a(2n-1)$,

where S_n = distance covered by the body in n^{th} second.

Graphical representation of motion

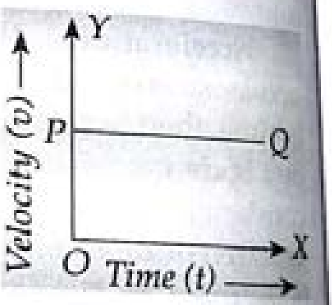
(i) Displacement-Time Graph :



If a body moves with a uniform velocity then displacement-time graph is a straight line as shown in the figure. The slope or gradient of the straight line provides speed. Also the greater the slopes of the straight lines, the larger the speed.

Obviously in the figure straight lines OP, OQ, and OR have increasing order of the speeds as $\theta_3 > \theta_2 > \theta_1$.

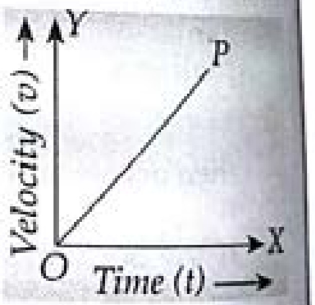
(ii) Velocity-Time Graph :



(a) Constant Velocity or Uniform Motion : If a body moves with a constant velocity in a uniform motion, then Velocity-Time graph is a straight line, parallel to Time-Axis as shown in the figure.

The straight line PQ represents uniform motion.

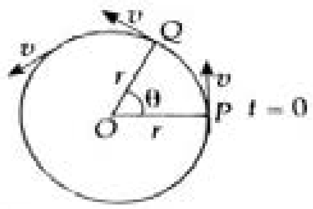
(b) Uniformly Accelerated Motion : If a body describes a uniformly accelerated motion in a straight line, then the Velocity-Time graph is a straight line as shown in the figure.



Obviously, straight line OP represents Velocity-Time graph of the uniformly accelerated motion.

Two Dimensional Motions : If the motion of a body is *described in two dimensional Co-ordinate axes or in a rectangular Co-ordinate axis*, then it is called *two dimensional motion*. The circular motion, projectile motion, motion of a canonical pendulum, etc. are all examples of two dimensional motion.

(i) Circular Motion : If a body describes its motion on a circular track or path, then the motion is called *circular motion*. In circular motion, since velocity of the body is tangential at every point of the track, its direction changes every



changes everywhere. This shows that as the magnitude of the velocity remains constant (speed constant) and velocity doesn't remain constant (as its direction changes) so the motion is accelerated. Thus motion of a body on a circular path with a *constant speed* is called *Uniform circular motion.*

Let P and Q are any two instantaneous positions of a body describing a uniform circular motion with linear velocity v. Here O is the centre of the circular track and r is its radius.

If a body describes an angular displacement in t sec and its position on the circular track changes from P to Q then the *angular velocity* of the body is defined as *angular displacement per unit time.* Thus angular velocity $\omega = \frac{\theta}{t}$ (expressed in rad / sec.)

If a body moves on a circular track and completes one revolution, then the time required for it is called Time period. The inverse of this time period is called angular frequency.

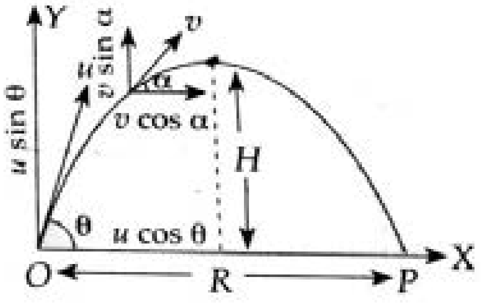
Thus $\omega = \frac{2\pi}{T} = 2\pi n$ Here, n is called angular frequency and T is time period. Thus $n = \frac{1}{T}$.

Also the linear velocity $(v) = \dfrac{\text{Circumference of the circular track}}{\text{Time elapsed}}$

or, $v = \frac{2\pi r}{T} = \left(\frac{2\pi}{T}\right)r = \omega \times r$ $\left(\because \frac{2\pi}{T} = \omega = \text{angular velocity}\right)$

Thus, linear velocity (v) = angular velocity (ω) × radius (r)

(ii) Projectile Motion : If a body is projected upward with a certain initial velocity u making an angle θ with horizontal direction, then the body describes a two dimensional motion whose path (trajectory) is *parabolic* and such a body is called *projectile.*



Here a unique physical phenomenon occurs. As the body starts its motion there is no acceleration in its horizontal direction, but in the vertical direction there is a constant acceleration (acceleration due to gravity). Thus, in the projectile motion the body describes its horizontal motion with constant velocity and its vertical motion with constant acceleration.

Terms and Expressions associated with projectile motion.

Time of Ascent (t_a) **:** It is the time taken by a body (projectile) to reach the maximum height (H). It is given by

$$t_a = \frac{u \sin\theta}{g}$$

Time of Descent (t_d) **:** It is the time taken by a body (projectile) to reach the ground at P from the maximum height (H). It is given by $t_d = \frac{u \sin\theta}{g}$

Thus $t_d = t_a = \frac{u \sin\theta}{g}$

(Here air resistance is assumed to be negligible)

Time of flight (t_f): It is the sum total of the time of ascent and the time of descent i.e. the total time taken to travel the distance *OP* (Horizontal distance by the body called *Horizontal Range* or *Range*.)

$$\text{Thus } t_f = t_a + t_d = \frac{u\sin\theta}{g} + \frac{u\sin\theta}{g} = \frac{2u\sin\theta}{g}$$

Maximum Height (H) : It is the maximum vertical distance travelled by a body (projectile) at which its velocity becomes Zero at glance. It is given by $H = \frac{u^2\sin^2\theta}{2g}$

Horizontal Range (R) : It is the total horizontal distance (*OP*) travelled by a body (projectile) in the total time of flight (t_f). It is given by $R = \frac{u^2\sin 2\theta}{g}$

Obviously range *R* would be maximum if sin 2θ be maximum. But max. value of sin 2θ = 1

$\Rightarrow \sin 2\theta = 1 = \sin 90^\circ \Rightarrow \theta = 45^\circ$

Thus *any projectile would have max. range* if θ (*angle of projection*) = 45° and it would be $R_{max} = \frac{u^2\sin 90^\circ}{g} = \frac{u^2}{g}.1 = \frac{u^2}{g}$

Also if the angle of projections are θ and (90° − θ) then *horizontal range* R would be the *same* in *both cases,* whatever be the initial velocity of projection, max. height attained, time of flight, etc.

Equation of the trajectory of the projectile

The overall equation of the trajectory of any projectile, whatever be the individual parameter, is given by

$$y = (\tan\theta)\,x - \frac{gx^2}{2u^2}\sec^2\theta. = (\tan\theta)\,x - \frac{g}{2(u\cos\theta)^2}\cdot x^2$$

Obviously, it is the *equation* of a *parabola*. That's why *every projectile* traces out a *parabolic trajectory (path).*

Newton's Laws of Motion : Firstly in 1687 Sir Isaac Newton, who was a great mathematician of his time, propounded the laws of motion in his book *Principia*. There are three laws of motion.

First Law (*Law of Inertia*) : A body continues in its state of rest or uniform motion in a straight line in the same direction unless some external force is applied to it. This is *Newton's first law of motion.*

The tendency of bodies or objects to remain in the original initial state of rest or uniform motion is called *inertia*. Inertia is of two types (i) Inertia of rest and (ii) Inertia of motion. Also the external force which is accountable to change the state of the bodies provides us the definition of force.

Examples of inertia : (i) If a train suddenly starts to move from the position of rest then a passenger sitting in it leans in the opposite direction. This happens due to the inertia of the body of the passenger. Due to sudden start of the train the lower part of the body of the passenger which is in contact with the train comes in motion whereas the upper part, due to inertia of rest, stays at rest. Thus, there is a relative displacement of the two parts of the body of the passenger and consequently the passenger leans in the opposite direction.

(ii) To remove dirt from a coat we hit it with a stick. On being hit the coat comes into motion but the dirt, due to its inertia remains at rest and so gets detached from the coat and falls off.

(iii) Before taking a long jump an athlete runs for a while and then takes a leap. By running for a while he gains inertia of motion which helps him take a longer *jump*.

(iv) While alighting from a slowly moving train one must run for a short while in the direction of the moving train and then let off the train. When you set your foot on the ground, the lower part of your body comes to rest instantaneously but the upper part of the body continues to move in the direction of the train. Due to relative displacement you are liable to fall forward and hurt yourself. If you run for a short while all the parts of the body will be in the same state and hence there will be no relative displacement of the different parts of the body.

Second Law (*Law of Measurement of Force*) : The rate of change of linear momentum ($p = mv$) of a body is proportional to the force applied and it takes place in the direction of the force. i.e. $\boxed{F \propto \frac{dp}{dt}}$,

or, $F = k\frac{dp}{dt} = k\frac{d(mv)}{(dt)} = km\frac{dv}{dt}$ (here mass m is constant)

Where, k = proportionality constant

$= kma$ (as $a = \frac{dv}{dt}$ = acceleration)

If the proportionality constant $k = 1$ then $F = ma$.

$\Rightarrow$ Force = mass × acceleration.

If $F = ma = m\frac{dv}{dt} = 0$, then no acceleration would be produced.

If the *acceleration* of the body is *zero* ($a = \frac{dv}{dt} = 0$) then the body will move either with a *constant velocity* or be in *a position of rest*. This implies that in the absence of an external force the body either *moves* with *constant velocity* or *comes* to *rest*. This also concludes that in the *absence* of an *external force* the inertia of a body is *conserved*.

Third Law *(Law of Action and Reaction)* : To every action, there is an equal and opposite reaction. Action and reaction act on different bodies. Since their lines of action are different, the resultant force is not zero. This is Newton's Third law of motion.

Examples : (i) A rocket whose mass decreases continuously due to ejected mass in the form of gases during its forward motion.

(ii) During firing of a bullet the gun recoils back with a great force.

(iii) To drive water boat forward the bamboo stick is pressed into the land of water.

(iv) During pulling water from the well sometimes the rope breaks and the man falls behind the well.

Units of Force : The S.I. Unit of force is *Newton*. *Forces* are *defined* by *Newton's first law* of *motion* and *measured by Newton's second law of motion*.

By Newton's second law $F = ma$. Here if $m = 1$ kg and $a = 1$ meter / second^2, then $F = 1$ N. Thus 1 Newton is the force required to produce an acceleration of 1 ms^{-2} in a body of mass 1 kg.

The CGS unit of force is *Dyne* and 1N = 10^5 dyne.

Another unit of force is kg-wt which is also used for *Gravitation.* 1 kg-wt is the force required resulting from the acceleration of gravity on the body of 1 kg mass. Thus by Newton's second law, Force due to gravity = mass × acceleration due to gravity. The force of gravity acting on a body is the weight of the body.

Thus weight $(W) = mg$.

Here the value of g (acceleration due to gravity) = 9.8 ms^{-2}

Thus, 1 kg.weight = 1 kg × 9.8 ms^{-2} = 9.8 kg.ms^{-2} = 9.8 N.

Linear Momentum and Impulse : The product of the mass of a moving object or body with its velocity (constant) is called Linear Momentum and it is a vector quantity.

Thus momentum (p) = mass × velocity

$$\Rightarrow \quad p = mv.$$

The S.I. unit of the linear momentum is kg.ms^{-1}

If any external force is operative on an object or a body for a very short span of time, then the product of this external force and the time is called *Impulse* and the force is called *Impulsive Force.*

Thus Impulse (J) = Force × time interval

$$\Rightarrow \quad J = F\,.\Delta t = \frac{\Delta p}{\Delta t} \cdot \Delta t = \Delta p$$

$$\Rightarrow \quad J = \Delta p = \text{change in linear momentum.}$$

Thus *impulse* is also defined as *change* in the *linear momentum* of the body for a *short span of time.*

The S.I. Unit of the impulse is that of linear momentum and given by kg.ms^{-1}

Examples of the linear momentum and the impulse

(i) Cricket players while taking a catch move their hands in the direction of the motion of the ball to avoid maximum injuries and for minimum hurt.

(ii) In heavy and light vehicles springs and shock observers are installed to avoid exertion and for comfortability.

(iii) To hit nail in depth, a heavy hammer is used.

Law of conservation of linear momentum

The *linear momentum conservation* is the *outcome* of *Newton's second* and third *law of motion.* Under the mutual action and reaction of two or more bodies, free from external forces, the algebraic sum of the linear momenta of the bodies in any assigned direction remains conserved. Thus, in general, *if no external force is operative on a system of particles or bodies under the mutual action and reaction of the particles, the momentum of the system in any direction remains conserved.* This is the *law of conservation of linear momentum.*

Example

(i) When a shot is fired, the cannon recoils. This is an example of the law of conservation of momentum. Here the system (*Shot + Cannon*) is at rest with respect to reference frame fixed to the earth. When a shot is fired with a velocity say v, it gains a certain velocity, say V and by the conservation law the cannon must also acquire the same velocity in the opposite direction so that the algebraic sum of the momenta becomes zero. If m and M be the masses of shot and cannon, then by conservation law of linear momentum;

$$mv + MV = 0 \qquad \text{or, } V = -\frac{mv}{M}$$

$-ve$ sign indicates that V must be necessarily opposite to v. This velocity of the cannon is called the *velocity of recoil.*

(ii) In the process of collisions, elastic or inelastic the total linear momentum before collision is equal to the total linear momentum after collision. Thus, total linear momentum of the system of colliding particles is conserved.

If m_1 and m_2 the two masses of colliding particles, u_1 and u_2 are the velocities of the respective particles before collision and v_1 and v_2 are the velocities of the particles after collision.

Then by the law of conservation of linear momentum

Total linear momenta before collision $= m_1 u_1 + m_2 u_2$

Total linear momenta after collision $= m_1 v_1 + m_2 v_2$

Thus $m_1 u_1 + m_2 u_2 = m_1 v_1 + m_2 v_2$

Elastic and Inelastic collision : When two particles or bodies directly strike (collide) in such a way that the total kinetic energy and the total linear momentum of the colliding particles during the collisions remain constant (conserved) then it is called elastic collision. If the relative velocity of separation and approach is equal for the two colliding particles, then the collision is said to be perfectly elastic and the particles of equal masses mutually exchange their velocities to each other after the collision.

But when two particles or bodies collide in such a way that the total linear momenta of the colliding particles or bodies remain constant or conserved but the total kinetic energy of the colliding particles system is not constant (conserved) then it is called inelastic collision.

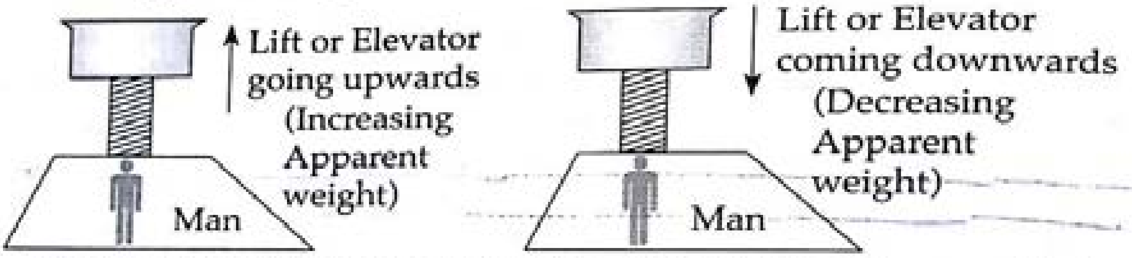
Rocket Motion *(A system of variable mass)* : The basic principle on which Rocket motion occurs or a Rocket is propelled is the *Newton's third law of motion* and the *law of conservation of linear momentum.*

A typical example of variable mass system is that of a rocket motion from which hot gases keep on escaping, thereby continuously decreasing its mass. A rocket may use either a liquid or a solid fuel. In the former case the fuel (*like liquid H_2 or liquid paraffin*) and a suitable oxidizer (like O_2, H_2O_2 or HNO_3), stored up in separate chamber are injected into a combustion chamber where the fuel is burnt. In the latter case, the fuel itself carries its own oxidizer and hence a separate chamber is not needed. In both cases large quantity of the heat of combustion is produced, which largely raises the internal pressure and temperature of the chamber and burnt up gases (like CO, steam etc) are pumped out from an orifice at the back or the tail end of the rocket in the form of a high velocity stream called the *jet.* Consequently the rocket is propelled forward (opposite to the direction of the jet). Here the momentum lost by the jet of the fuel gases must be equal to the momentum gained by the rocket.

A multistage rocket is just a combination of a number of rockets either joined consecutively in series or one inside the other or with the rear part of one inside the nozzle of the other. In all the three types, the first stage is the largest in dimension and in weight and the last stage is the smallest and the lightest. The first stage rocket is used first and when its fuel is all burnt up and it has done its job, it gets detached and discarded, with the second stage taking over the task of producing further acceleration. This too, in turn is detached when its fuel is burnt up and the third stage rocket takes over. The velocity thus goes on increasing at each stage by the same amount as it does in a single stage rocket. The fuel consumption and thrust for the first stage are about 100 times more than for the third stage and the fuel stock carried by it about 60 times that carried by the third stage.

Any rocket (Single Stage) can attain the *maximum velocity* of 3.5 kg/sec due to limitations of conventional chemical fuels, cooling problems etc. Thus a *single stage rocket is incapable* to *put space satellites* in the *orbits* or *escape through the earth's gravitation field.* Thus a *multistage rocket* is designed and fabricated to *enhance* and *achieve* a *greater velocity.*

The Apparent weight of a body in a lift or elevator.


Lift or Elevator going upwards (Increasing Apparent weight)
Man
Lift or Elevator coming downwards (Decreasing Apparent weight)
Man

The lift or elevator is a simple machine installed in various multiplexes through which people are transported in multi storied buildings for the business and other officials purposes.

If M be the mass of a man elevated on the lift and F be the apparent weight of the man, then for the lift going upwards :

$$F - Mg = Ma$$

$$\Rightarrow \; F = Mg + Ma \quad = M(a + g) \qquad \text{[larger wt.]}$$

Here a = acceleration of the lift by which it goes up or down and

g = acceleration due to gravity

Now for the lift coming downwards $F + Mg = Ma$

$$\Rightarrow \; F = M(a - g) \text{ (Lesser wt.)}$$

Thus, the man elevated on the lift experiences larger weight of its own in *going up* and experiences *lesser weight* in *coming down*.

Types of Forces or Interactions : Everywhere in our nature there are four types of forces—

(i) Gravitational Force
(ii) Weak Force
(iii) Electromagnetic Force
(iv) Nuclear Force

(i) Gravitational Force : Every body in our universe *interacts (attracts)* with each other which is called *Gravitation* and the occurrence of such interactions are due to the individual masses of the bodies where gravitational fields are confined and *respondent* to each other.

The *Gravitational force* is the *weakest* among all existing forces and it is negligible for all lighter and smaller bodies but becomes significant and considerable in all celestial bodies. Since the value of *Gravitational constant* (G) measured in *Torsion balance* by Cavendish was very small only 6.67×10^{-11} $Nm^2.kg^{-2}$, gravitational force for smaller bodies is negligible and can not be realized.

(ii) Weak Force : The concept of *weak force* came into existence firstly in *Yukawa's meson theory* when explanation of β – decay was propounded. In the atomic nucleus, electron emission (β – particle decay) takes place spontaneously during the conversion of neutron into a proton by ejecting a π meson. This π meson decays almost instantly into an electron (e^-) and an anti neutrino ($\bar{\nu}$).

Thus; n (neutron) → p (proton) + π^{-1} (π–meson) → p (proton) + e^- (electron) β–decay + $\bar{\nu}$ (anti neutrino)

Here neutron is converted into proton by the exchange of π–meson and consequently interaction between *electron* (*β–decay*) and *antineutrino* is due to *weak interaction.*

(iii) **Electromagnetic Force :** Electromagnetic force operates on all charged particles and provides atomic and molecular binding forces. Thus electromagnetic interactions are charge-dependent (attractive as well as repulsive).

The electric and magnetic forces compose the electromagnetic force which acts by means of photon or quanta. If both electric and magnetic forces exist, then it is called *Lorentz's force* given by $\boxed{F = qE + qvB\sin\theta}$

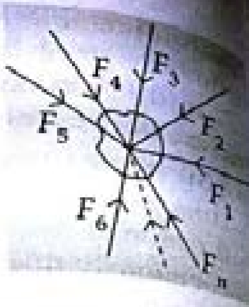
Static electromagnetic

Where, q = Charge of the particle
E = Electric field strength
v = Velocity of the charged particle
B = Magnetic field intensity
θ = Angle between velocity and magnetic field

(iv) Nuclear Force *(Strong Force)*: Among *all the forces* found in nature, *nuclear force* is the *strongest force* which basically exists within atomic nucleus between proton–proton, proton–neutron, and neutron–neutron within the range up to 10^{-15} meter. *Experimental evidences* of the nuclear Physics observe that *nuclear forces* are primarily *attractive, non-electrical, non-gravitational (not central forces), extremely strong* but *spin dependent* and the *magnitude* of the force is *same* for proton-proton, proton-neutron and neutron-neutron. Explanation of the nuclear forces was given in detail by *Yukawa's Menson's theory.* Some scientists also assume that the nuclear forces originate through the mutual interaction of two *quarks.*

Comparison among four types of Interactions :

Interaction	**Relative magnitude**	**Carrier particle**	**Characteristic Time**
Nuclear (strong) interaction	1	π –meson	10^{-23}sec
Electromagnetic interaction	10^{-3}	photon	10^{-20}sec
Weak interaction	10^{14}	Intermediate Bosons	10^{-10}sec
Gravitational	10^{-39}	Graviton	10^{-16}sec



Balanced Force : If on a body various forces act at a time and if the resultant of all these forces is zero then the body is said to be in an equilibrium state and at this moment all forces are called a balanced force.

Thus mathematically at equilibrium

$$F = F_1 + F_2 + F_3 + F_4 \text{ .... } F_n$$

$$= \sum_{i=1}^{n} F_i = 0$$

Unbalanced Force : If on a body two or more forces operate in such a way that the body (object) starts to move towards any force, then the force acting on the body is called unbalanced force.

Frictional Force : It is our common experience that when a block (body) is set in motion on the floor it eventually comes to rest. This means that an *opposing force retards its motion* and this force is called *frictional force.*

This force is neither gravitational nor elastic in nature. This force also occurs in pair. Actually, whenever a body slides over another body, each body exerts a frictional force to each other along the surfaces of contact. The *frictional force* on *each body* acts in a direction *opposite* to its *motion.*

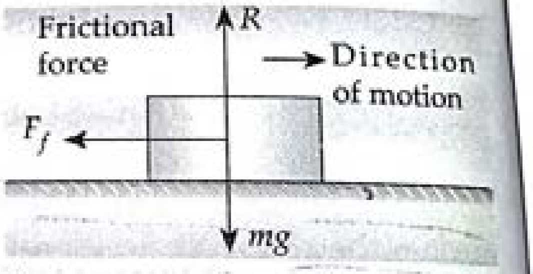
As the motion of a body increases, the force of friction acting on it also increases.

Thus, force of friction (F_f) is directly proportional to its normal reaction (R).

$\Rightarrow$ $F_f \propto R$ or, $F_f = \mu R = \mu mg$.

where, μ is a constant and called coefficient of friction.

m = mass of the sliding body
g = acceleration due to gravity



Types of frictional forces

(i) Static frictional force
(ii) Kinetic or sliding frictional force
(iii) Rolling frictional force

(i) Static frictional force : If a body kept on any surface tries to move by any force applied on it but doesn't move, then the force operative within the surfaces of both is called static force of friction which is equal to the applied force but in opposite direction.

(ii) Kinetic or sliding frictional force : If a body on any surface is sliding or moving uniformly, then the force acting within the surfaces of both is called kinetic or sliding frictional force.

(iii) Rolling Frictional force : If a body rolls on another body (or surface), then force acting within the surfaces of both is called rolling frictional force.

Static force of friction > Kinetic or sliding force of friction > Rolling force of friction i.e. $\mu_s > \mu_k > \mu_r$. Here; μ_s, μ_k and μ_r are called coeff. of static, kinetic and rolling friction.

Characteristics of frictional forces

(i) The *frictional forces* acting within the two surfaces of the bodies *do not depend on their contact area, rather they depend* upon the *nature of the surfaces.*

(ii) The *static force of friction* is the *largest* and the *rolling force of friction is the least or the smallest.*

(iii) To reduce friction between two rubbing surfaces, a suitable oil or grease called *lubricant* is used which is generally introduced between the *two surfaces.* This ensures smooth functioning of the different parts of a machine and prevents them from getting unduly heated. The lubricant with *ball-bearings* intervenes between the surfaces. Thus it prevents them from coming into direct contact and the kinetic friction, converted into sliding friction and that is why force of *friction,* diminishes too.

(iv) It is also observed that *force of friction* between the surfaces of the *solid–solid* is the largest while in *liquid-liquid* it is *less* than the former whereas it is *least in solid-gas surfaces.*

Advantages

(i) If the force of friction doesn't exist on the road where vehicles run, wheels will start to slip and would ultimately derail.

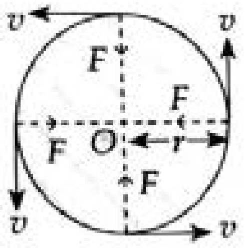
(ii) Due to the forces of friction man stands and moves.

Disadvantages

(i) Due to the forces of friction, energy is lost too much in machines and tools and ultimately the machines are damaged.

(ii) Due to the forces of friction the inner components (parts) of machines generate tremendous amount of heat (thermal energy) which distorts the machines.

Centripetal Force *(Real Force)* : When a body moves on a circular path of radius r with uniform speed v, then an acceleration of magnitude v^2/r acts towards the radius and it is called ***Centripetal** acceleration (Centre Seeking) or radial acceleration.* But by Newton's second law of motion, this acceleration is produced by a corresponding force (every accelerated body has a force) called *Centripetal Force* directed *inwardly* towards the radius i.e. in the direction of acceleration. Thus a body of mass m moving with a constant speed v (uniform circular motion) on a circular path of radius r has a magnitude of the centripetal force.



But F = mass × acceleration

$$F = \frac{mv^2}{r} = \frac{m\ \omega^2 r^2}{r} = mw^2 r \quad (\because v = \omega r)$$

where, ω = angular velocity of the body.

Thus centripetal force is a *real force* acting on the body to *maintain* a *circular motion* or to remain on a circular track. *Without* it circular motion is *not possible.*

The centripetal acceleration always acts radially inwards, while velocity (linear) acts tangentially outwards.

Thus the *centripetal acceleration* and *linear velocity* of the *body* describing a circular motion are *perpendicular* to each other throughout the motion. Also at each and every instant the direction of centripetal acceleration (radially inward) and its velocity (tangentially outward) change regularly.

This implies that in the circular motion the body moves on a circular track with *variable centripetal acceleration* and *variable velocity* (*constant speed*). But as tangential velocity changes at each and every instant, another acceleration (due to change in the direction of velocity) is also produced simultaneously. Thus a body describing a uniform circular motion with a constant speed experiences two types of acceleration–one *centripetal acceleration* acting *radially inward* and another *tangential acceleration acting tangentially* outward.

If a_c and a_t be the centripetal and tangential accelerations, then the resultant acceleration acting on the body in uniform circular motion would be expressed as below :

Resultant acceleration (a)

$$= \sqrt{[\text{centripetal acel.} (a_c)]^2 + [\text{tan gential acel.} (a_t)]^2}$$

$$\Rightarrow \quad a = \sqrt{(a_c)^2 + (a_t)^2}$$

The nature of the centripetal force is not different from other ordinary forces like Gravitational forces, Frictional forces, Electrostatical Columbian forces etc, but it is simply a way of describing the behaviour of a force responsible for the maintenance of the circular motion.

Examples : (i) In the planetary motions of sun and planets and also in the orbital motions of planets and satellites (both natural and artificial) the Centripetal forces are counterbalanced by Gravitational forces.

$$\text{Thus;} \quad \frac{mv^2}{R} = \frac{GM_m}{R^2} = m\omega^2 R \qquad (\because\ v = \omega R)$$

(ii) The centripetal force is necessarily equal to the force of friction of the wheels of the vehicle acting on the contact surfaces at the overturning of the road.

$$\text{Thus;} \quad \frac{mv^2}{r} = \mu F = \mu mg$$

where μ = coeff. of friction.

(iii) An orbiting electron experiences a centripetal force about a massive nucleus which is equal to the electrostatical forces of attraction.

$$\text{Thus;} \quad \frac{mv^2}{r} = \frac{1}{4\pi \epsilon_0} \frac{(Ze)e}{r^2} = \frac{1}{4\pi \epsilon_0} \frac{Ze^2}{r^2}$$

where, e = electronic charge, Ze = charges on the atomic nucleus

Centrifugal Force or Pseudo Force or Fictitious Force

In a uniform circular motion a centripetal force (real force) of magnitude $\frac{mv^2}{r}$ acts on the body in *inertial frame* (*Non-accelerating*). But if an observer is confined on the circumference of any circular path (track) anywhere, then he experiences a *fictitious force acting outwardly* called *centrifugal force* and due to its *fictitious existence*, it is also called a *pseudo force*. Thus centrifugal force is a fictitious force appearing in a *non-inertial frame* whose magnitude is *equal* to that of the *centripetal force* but *oppositely directed* to it. This force is *not* the *reactionary force* of the centripetal nature but a *virtual imaginary force that appears* by the *virtue of inertia*. That's why it is also called an *inertial force*.

Example : (i) If a man is travelling in a car in a straight line path and the car suddenly turns right, then the man realises a severe shock (push) towards the left. This happens because as the car turns, a centripetal force around the radius of curvature of the path is generated which is counter-balanced by the force of friction of the wheels of the car. But this centripetal force is not balanced by the man, so a shock is felt by the man which comes through the *virtue* of *inertia*. This is the required centrifugal force which acts outwardly.

(ii) The person sitting in a *merry-go-round* realises an outer push tangentially due to the appearance of a centrifugal force.

In the study of any physical phenomenon, the position of a system or body is made to be fixed and the distances of other bodies are measured called *reference frames*. It is of two types (i) Inertial (Non-accelerating) and (ii) Non-inertial (accelerating).

Inertial frames are those in which *inertia of any body remains conserved*. Thus this frame is either *in rest* or in a *uniform motion* in a straight line i.e. no force, no acceleration concept exists.

But if the force or the acceleration exists in a particular frame it is called non-inertial. Newton's laws of motion are applicable only in inertial frame of reference.

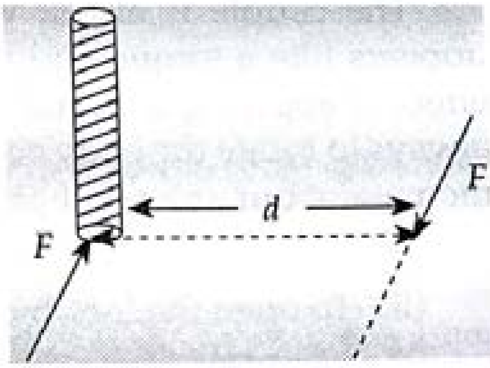
Application

Centrifuge : A device by means of which light particles and heavy particles are separated to each other.

(i) Cream Separator : In a cream separator, a vessel containing milk is rotated fast. Being lighter the cream collects in a cylindrical layer around the axis, whence it is drawn off and the skimmed milk is drained through an outlet fitted on the wall of the vessel. The particles, whose density is less than that of the liquid, are driven towards the axis of rotation and those whose density is greater than that of the liquid are driven away from the axis. Cream is lighter than milk, so it is separated from milk and collected at the axis.

(ii) The Centrifugal Drier : In laundries wet clothes are dried by packing them in a cylindrical vessel with perforated walls which rotated with a very high speed. Water particles stick to the cloths with a certain force which is called adhesive force. The water particles are not sufficient to keep them moving uniformly in a circle.

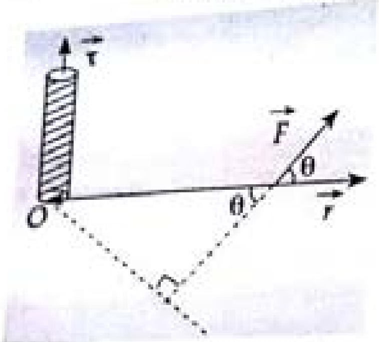
Torque or Moment of a force : The turning effect of a force about a point or a line is called the moment of force about that point or line which is called the axis of rotation. The turning effect of a force is dependent on the magnitude of the force and the perpendicular distance of its line of action from the axis of rotation.



The force turns or tends to turn the body either in clockwise or anti-clockwise direction. The direction of the moment of force is fixed by the direction in which the force turns or tends to turn the body. Generally the anti-clockwise direction is considered as a positive (+ve) direction of the moment of a force. For larger magnitude of the force, there must be a larger turning effect and its moment of force. Thus turning effect is too much appreciable for a larger moment of force and its perpendicular distance from the axis of rotation.

The moment of the force is defined as the product of the force and the perpendicular distance from the axis of rotation.

Thus, moment of force = Force × its perpendicular distance from the axis of rotation.



⇒ The moment of the force or torque

$$(\vec{\tau}) = \vec{r} \times \vec{F} = r\,F\sin\theta$$
$$= Fr\sin\theta$$

where;

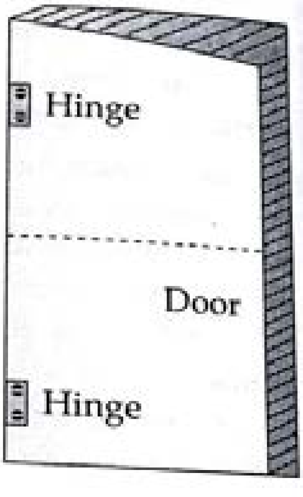
θ = angle between the force and the position vector.

The moment of a force or Torque is a vector quantity and its S.I. unit is N.m

Examples : (i) For the equal forces as far as larger distance from the hinges of any door it will be needed to apply some more moment of force and correspondingly the tendency of more turning will be appeared. That's why *handles* are installed and fixed at a *larger distance* from the *hinges* of the *door.*

(ii) The handle of a quern is kept distant from its pivot because through a smaller force (effort) the handle can be easily turned out (rotated).

(iii) Hand pumps of water have larger handles.

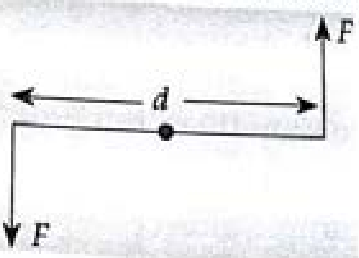


Couple : Two equal and opposite forces form a couple and it is defined as the product of the force and the couple arm.

Thus; couple = force × couple arm

$= F \times d$

The couple is also a vector quantity which appears like a torque and its SI unit is N.m. The effect of applying a torque or couple on a body is always to rotate the body because a couple will always have an unbalanced moment about any point or an axis of rotation.



Examples : (i) To rotate the steering wheel of the vehicle.

(ii) To open the lock by the key. (iii) To open the water-pump etc.

Simple Machines : The Simple Machines operate on the principle of couple or torque in which on a convenient point a force is applied and from

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another point weight is carried out. The Lever, Pulley, Inclined Planes and Screw Jack are the examples of Simple Machines.

Machines are equipments through which more heavy objects are carried by applying a lesser force.

The efficiency of machine is given by—

$$\text{Efficiency of a machine} = \frac{\text{Work done by the machine}}{\text{Input energy provided by the machine}} \times 100$$

The efficiency of any machine can never be 100 %.

Lever : Lever is a simple machine in which a straight or an inclined rod is made to turn or rotate at a point freely or independently. In every lever there are three points namely — Fulcrum, Effort and Load.

Examples : Tongs, Nut Cracker, Scissors etc.

Fulcrum : The fixed point about which the rod of the lever moves independently is called *Fulcrum*.

Effort : To use (operate) lever the force applied externally is called *Effort*.

Load : The weight carried by the lever is called *Load*.

Theory of Lever : The basic physical principle on which a lever operates is that the product of effort and effort-arm is equal to the product of the load and load-arm.

Thus; *Effort × Effort-arm = Load × Load-arm*

Mechanical Advantage of Lever : The ratio of the load carried by the lever to the effort applied is called the mechanical advantage of the lever.

$$\text{Thus mechanical advantage} = \frac{\text{Load or weight } (W)}{\text{Effort } (E)}$$

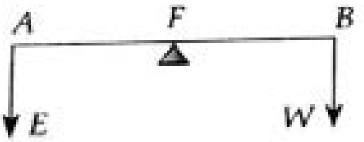
Types of Levers : On the basis of the relative positions of fulcrum, effort and load there are three types of Lever.

(i) First Type of Lever : In this type of lever the Fulcrum (F) is at midway between Effort (E) and Load or Weight (W).

$$\text{Mechanical advantage} = \frac{\text{Load or weight } (W)}{\text{Effort } (E)}$$

$$= \frac{AF}{BF} = \frac{\text{Effort arm}}{\text{Load arm}}$$

Example : Scissors, Brakes of a bicycle, balance etc.

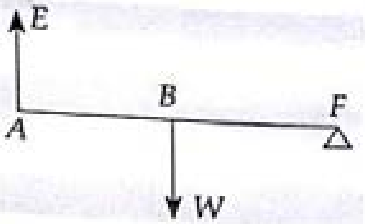


(ii) Second Type of Lever : In this type of lever the load (W) is at midway between the fulcrum (F) and the Effort (E).

$$\text{Mechanical advantage} = \frac{\text{Load } (W)}{\text{Effort } (E)} = \frac{AF}{BF} = \frac{\text{Effort arm}}{\text{Load arm}}$$

Such levers provide more than one mechanical advantages since $AF > BF$

Example : Nut cracker, Lemon squeezer, movable door on hinges, tobaco cutting machines etc.

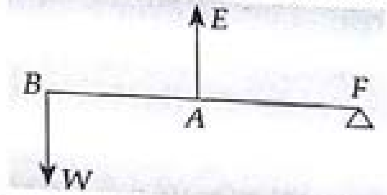


(iii) Third Type of Lever : In this type of lever the Effort (E) is located at midway between the Fulcrum (F) and the Load or Weight (W).

$$\text{Mechanical advantage} = \frac{\text{Load (W)}}{\text{Effort }(E)} = \frac{AF}{BF} = \frac{\text{Effort arm}}{\text{Load arm}}$$

Such type of levers provide mechanical advantages of less than 1, since $AF < BF$. Such levers are used and utilized to enhance the slow motion.

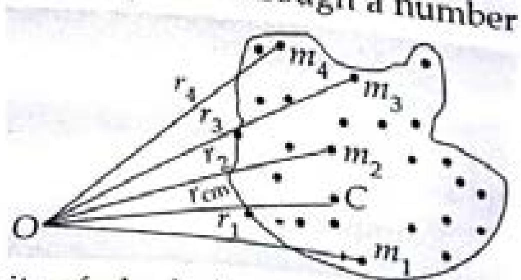
Example : Tongs, plough of the farmers, hands of a man etc.



Centre of mass : Every physical system of particles (body) is associated with a certain point whose motion is characterised by the system as a whole, and when a system moves under an external force then this point moves in a similar way as a single particle moves under the same external force. This is called *centre of mass* of the system.

Thus centre of mass of a body (system of particles) is a point where the whole (entire) mass of the body may be supposed to be concentrated so far the action of a system of parallel forces acting on the elementary masses is concerned. If a body (system of particles) is composed through a number of particles, say n of masses $m_1, m_2, m_3 \ldots\ldots m_n$ located at the distance (position vector) $r_1, r_2, r_3 \ldots\ldots r_n$ then the position of the position vector r_{cm} is defined as

$$\mathrm{r}_{\mathrm{c.m}} = \frac{m_1 r_1 + m_2 r_2 + m_3 r_3 \ldots\ldots + m_n r_n}{m_1 + m_2 + m_3 \ldots\ldots + m_n}$$



Centre of Gravity : The centre of gravity of a body (system of particles) rigidly connected together at a point where the whole mass of the body or the system may be supposed to be concentrated so far as gravity (force of attraction due to the earth) on the constituent particles of the body or the system is concerned. Also according to the principle of the law of gravitation every particle of a body near or upon the surface of the earth is attracted towards the centre of the earth. The vectorial sum of all ..

attractive forces on the particles is the total force with which the body is attracted towards the centre of the earth. This force is called the *weight* of the body and the point of application of this force is called the *centre of the gravity* of the body or the system.

For a larger body *centre of gravity* and *centre of mass* are two different points but for a *smaller body* these two are a *coincident point.*

Centre of gravity of some rigid bodies

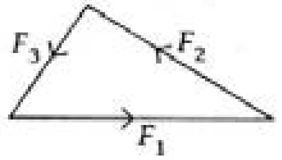
Bodies	**Position of the centre of gravity (C.G.)**
Uniform bar (rod)	Mid-point of the axis passing through the bar or rod.
Triangular solid body	The intersection point of the medians.
Rectangular or Square Solid	The intersections points of the diagonals.
Circular Lamina	Centre of the circle.
Conical Solid	At $\frac{1}{4}$th height on the axis of the cone from its base.
Hollow Cone	At $\frac{1}{3}$rd height on the axis of the cone from its base.
Solid Spherical body	Centre of the sphere

Equilibrium of Bodies : When a body under the action of several forces neither moves in a straight line nor rotates around a point then it is said to be in *equilibrium.*

Conditions for equilibrium : (i) The vector sum of all forces acting on a body along any assigned direction for translational equilibrium must be *zero.* Thus no linear motion occurs.

(ii) The algebraic sum of moments (torques) of all the forces acting on a body about any assigned point or line for rotational equilibrium must *vanish* (being zero). Thus no angular acceleration must exist.

If three forces acting on a particle as shown in the figure are capable of being represented in magnitude and direction by the three sides of a triangle taken in order, they (force) *produce an equilibrium.*

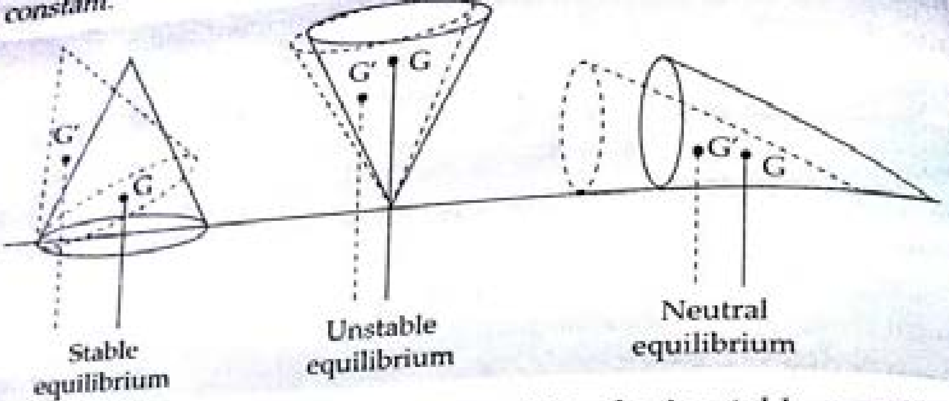


Types of Equilibrium : There are three types of equilibrium (i) Stable equilibrium (ii) Unstable equilibrium (iii) Neutral equilibrium.

(i) Stable equilibrium : When a body is in equilibrium in such a way that a slight displacement from this position produces a restoring force tending to return the body to the previous equilibrium, then body is said to be in *stable equilibrium.* In *stable equilibrium* the body possesses *minimum potential energy.*

(ii) Unstable equilibrium : When a body is in an equilibrium in such a way that any displacement from this position produces a force tending to push the body farther from the equilibrium position, then it is said to be in *unstable equilibrium.* In *this equilibrium position* the body possesses *maximum energy.*

(iii) Neutral equilibrium : When a body is in such a state of equilibrium that on displacing slightly from that position it (body) experiences neither a restoring force nor a deflecting force, then body is said to be in neutral equilibrium. *In this equilibrium position* the *potential energy* of the body *is constant.*



In the gravitational field a body is said to be in *stable equilibrium* when its *centre of gravity* (C.G.) *lies as below as possible.*

Universal conditions for the *stability* of *equilibrium*—

(a) The body must have *minimum potential energy.*

(b) The *vertical line* through the *centre of gravity* (c.g.) of the body must pass through the *base* of the body.

Examples : (i) The *tall Tower* of *Pisa* is extremely inclined for an observer and it *appears* that it may *fall down* at any moment, but it *never falls.* In fact it has been surviving (existing) since centuries. The *reason* for its *stability* is that the *vertical line* passing through the *centre of gravity* (c.g.) lies within the *base* of the *tower.*

(ii) *A double-decker bus* is found to be in *danger* of overturning if *more passengers* are *seated* on the *upper deck.* If there are more passengers on the upper deck, the *c.g.* of the *system* (bus+passenger) will be *shifted upward* and the *stability* of *equilibrium* will be *reduced.*

(iii) A man carrying a *bucket completely filled* of *water leans forward.* The man leans outward to attain an equilibrium position. When he *leans forward* the *vertical line* through the c.g. of the system (man + bucket) *passes* through the *base* of the *system* (space between his feet).

3. Work, Power and Energy

Work : When a constant force *F* acts on a particle and the motion of the particle takes place in a *straight* line in the *direction* of the *force,* the work done by the force is defined as the product of the magnitude of the force *F* and the distance *x* through which the particle moves.

Thus the work $(W) = F \cdot x$

However a force acting on a particle may not act in the direction in which the particle moves. Here the work done by the force is defined as the product of the component of the force along the line of motion of the particle.

If θ be the angle made by F with the line of motion of the particle, then by the definition of work; $W = (F\cos\theta)\cdot x = F\cdot(x\cos\theta)$

or, work done by a force = force × displacement along the force.

Work is a scalar quantity and the SI unit of Work is N–m which is called Joule (J).

The value of the work will be maximum at $\theta = 0°$

and minimum at $\theta = 90°$

$$\Rightarrow \quad W_{max} = Fx$$

$$W_{min} = 0$$

Power : The power of an agent is defined as the rate at which work is done. The average power delivered by an agent is the total work done by the agent divided by the total time interval.

Thus power $(P) = \dfrac{\text{work done }(W)}{\text{time interval }(t)}$

The instantaneous power of an agent is $P = \dfrac{dW}{dt}$

The SI unit of power is watt; 1 watt $= \dfrac{1\text{ Joule}}{\text{sec}} = 1\,\dfrac{\text{N}-\text{m}}{\text{sec}}$

The power of Machines are expressed in Horse Power (H.P.) and

1 H.P. = 746 watt.

Watt-second (Ws) - It is a unit of work.

Watt-hour (Wh) – It is also another unit of work.

⇒ 1Wh = 3600 Joule.

Kilo Watt-hour (kWh) – It is also the unit of work (energy)

$$\begin{aligned} 1\text{ kWh} &= 1000\text{ watt hour} \\ &= 1000\text{ watt} \times 1\text{ hr.} \\ &= 1000\text{ watt} \times 3600\text{ sec} \\ &= 3.6\times10^{6}\text{ watt sec} \\ &= 3.6\times10^{6}\text{ Joule} \end{aligned}$$

Thus, W, kW, MW, and H.P. etc. are the units of power;
while Ws, Wh, kWh, etc. are the units of work (energy).

If the force applied on a body is not constant, rather varies with distance, then the total work done by the force = work (W) = $\int F\cos\theta\, dx$

The work done in stretching a spring through a distance $x = \frac{1}{2}kx^2$, where k = a spring constant.

Energy : Energy of a body is its capacity of doing work. In Mechanics (General Physics) a body is capable of doing work under two circumstances–

(i) When it is in motion and (ii) When it is situated (located) in a field or when it is strained.

Thus two types of energy usually coexist— one due to the motion and the another due to the field or position.

Kinetic Energy : A body describing motion acquires a linear velocity and develop a capacity of doing work which is called kinetic energy of the body.

If m be the mass of the body having a velocity v, then kinetic energy of the body is given by

$$K.E. = \frac{1}{2}mv^2 = \frac{1}{2}(mv)^2 = \frac{p^2}{2m} \qquad (\because p = \text{linear momentum} = mv)$$

Thus, if the mass of the body is made double then its kinetic energy will become double, while if either velocity or linear momentum of the body is double, its $K.E.$ will become four times as that of the original.

Potential Energy : If a body develops a capacity of doing work due to its position or field, it is called the potential energy of the body.

If m be the mass of the body and h be the height or position of the body where acceleration due to gravity is operative, then potential energy of the body is given by $P.E. = mgh$. where; g = acceleration due to gravity.

When a bullet strikes (hits) a target it penetrates through the target and works against the resisting force offered by the target. This is the K.E. of the body and is measured by the work it can do in being brought to rest. When the body is kept in a field, it works due to its position in the field. This is obviously $P.E.$ Thus the unit of energy is obviously the same as that of work.

Conservative and Non-Conservative forces : A force is said to be conservative, if the work done by it on any particle that moves between two points depends only upon these two points and not on the path followed. A force is non-conservative if the work done by the force on a particle that moves between two points depends on the path taken between those points. Thus a force is said to be conservative if the work done by the force on a particle in a round trip is zero. A force is said to be non-conservative if work done by the force on a particle in a round trip is not zero.

Examples : The Gravitational force, Electrostatical force, Adhesive and Cohesive forces etc. are conservative forces. Viscous force, frictional force, damping force etc. are non-conservative forces.

Law of Conservation of Energy : Energy may be transformed from one form to another but it can't be created or destroyed and the total energy of any body or system is constant. Also whenever any energy in any form disappears, then the same amount of energy appears in another form. This is called the law of conservation of energy.

Transformation of Energy

Equipments / Instruments	Transformation of Energy
Solar Cell	Solar energy into Electrical energy
Dynamo	Mechanical energy into Electrical energy
Electric Motor	Electrical energy into Mechanical energy
Microphone	Sound energy into Electrical energy

Equipments / Instruments	Transformation of Energy
Loudspeaker	Electrical energy into Sound energy
Musical Instruments	Mechanical energy into Sound energy
Bulb/Tube	Electrical energy into Light energy
Heater	Electrical energy into Thermal energy
Candle	Chemical energy into Light energy and Thermal energy
Coal	Chemical energy into Thermal energy
Electric Cell	Chemical energy into Electrical energy
Heat Engine	Thermal energy (Heat energy) into Mechanical energy

4. Gravitation

Gravitation is the weakest interaction or force among all the four types of interactions existing in our Universe. Each and every body interacts (attracts) each other by virtue of its mass. This is called *Gravitation*.

Newton's Law of Gravitation

In our universe the force of interaction acting among any two bodies is directly proportional to the masses of the bodies and inversely proportional to the square of the distance between the bodies.

If m_1, m_2 be the masses of two bodies at r distance then according to the Newton's law of gravitation

$$F \propto m_1, m_2, \qquad F \propto \frac{1}{r^2}$$

$$\Rightarrow \quad F = G\frac{m_1 m_2}{r^2}$$

where G is called Universal Gravitational Constant

$= 6.67 \times 10^{-11}\ \text{Nm}^2\text{kg}^{-2}$

Gravity : As in Newton's law of gravitation the forces of interaction exist among any two bodies, but if in these two bodies one body is the Earth, then this gravitation is called gravity and by this force of gravity the Earth attracts everybody towards its centre. If a body is projected upwards freely, then due to the force of gravity it falls back.

Acceleration due to gravity (g) : If a body is dropped freely and it executes a free falling motion, then as the body comes near the Earth's surface then its velocity increases and the acceleration produced is called acceleration due to gravity. If m be the mass of any body describing a free falling motion then due to the presence of force of gravity the weight of the body = mg.

where $g = 9.8\ \text{ms}^{-2}$ or $32\ \text{ft s}^{-2}$ = acceleration due to gravity (Near the earth's surface)

In SI unit 'g' is expressed in ms^{-2} or N. kg^{-1}.

Relation between Universal Gravitational Constant (G) and the acceleration due to gravity (g).

If the earth is supposed to be a homogeneous solid sphere of mass M_e and another body of inertial mass m be (located) on the surface of the earth.

Then the force of interaction on the body of mass $m = \frac{G M_e m}{R_e^2}$;

where R_e = radius of the earth

Now, by Newton's second law of motion.

Force = *inertial mass* × *acceleration* = mg

$$\text{Thus } \frac{G M_e m}{R_e^2} = mg$$

$$\text{or, } g = \frac{G M_e}{R_e^2}$$

(Here, we assume that the inertial mass is equal to the gravitational mass.)

Obviously, the value of the acceleration due to gravity (g = 9.8 m/s^2) doesn't depend upon the mass of the body. Thus two bodies of different masses (if air resistance is to be negligible) fall freely and they (both) have the same value of g near the earth's surface. This shows that if two bodies of different masses, shapes and sizes are dropped in a vacuum from the same height, then both will reach the ground (surface) simultaneously. In the presence of air, the viscous drag, buoyancy etc. the motion (free falling) of the bodies are affected and thus the heavy body comes down earlier than lighter body.

Variation in acceleration due to gravity (g) : At the latitude of 45° and at the sea-level the standard value of g is 9.8 m/s^2 or 32 ft/sec^2

But the value of g is not constant and varies from place to place.

(a) Due to the spheroidal (Oblate Spheroid) shape of the earth

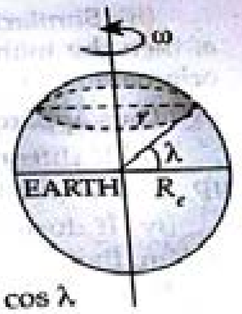
As derived above $g = \frac{G M_e}{R_e^2}$ and since the equatorial diameter is larger than the polar diameter, the value of g in the equatorial region is less than that in the polar region.

Thus; g = max. (At poles)

g = min. (At equator)

(b) Due to the axial rotation of the earth : If a body of mass m is kept on the earth's surface at any place whose latitude is λ then due to earth's rotation the weight of body is observed to have changed. This changed weight is the apparent's weight of the body. Obviously an apparent weight appeared due to variation in g.

In fact the body describes (traces) a circle of radius $r = R_e \cos \lambda$ due to earth's rotation.



The expression of the apparent weight is derived as—

Apparent wt $(mg') = mg - m\omega^2 r \cos^2 \lambda$

Thus, apparent acceleration due to gravity

$= g' = g - \omega^2 r \cos^2 \lambda$

But at the pole $\lambda = 90°$

$\Rightarrow$ $g' = g$ (max. at the poles)

At the equator $\lambda = 0°$

$\Rightarrow$ $g' = g - \omega^2 r$ (At the equator)

Obviously, if the earth stops to rotate then

$\omega = 0$ and here $g' = g$

$r = Re \cos \lambda$

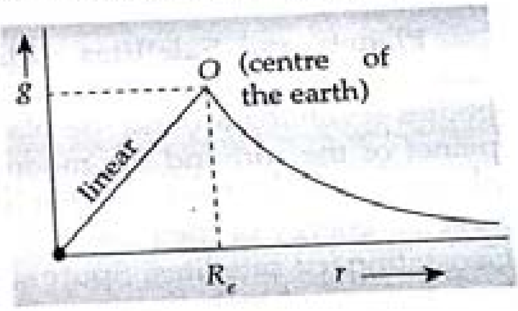
ω = angular velocity

λ = latitude of the place

If the earth's rotation increased 17 times of the present value, then the weight (apparent wt.) at the equator will be zero.

Obviously, the value of g increases on decreasing the value of angular velocity of the earth and vice-versa.

(c) With distance from the Centre of the Earth : Here the graphical representation of the variation of g with distance has been displayed—



The value of $g = 0$ at the centre of the earth. It increases linearly with distance up to the surface of the earth and then decreases rapidly and again becomes zero at infinity. The acceleration due to gravity g is maximum on the surface of the earth.

(d) Variation in going up from the earth's surface and coming down from the earth's surface.

(i) The value of g decreases in going up. If any body goes h height from the earth's surface, then the value of g decreases and say g' which is given by $g' = g\left(1 - \frac{2h}{R_e}\right)$

(ii) The value of g also decreases in coming down. If any body comes down to h height from the earth's surface, the value of g decreases and we say it g' which is given by $g' = g\left(1 - \frac{h}{R_e}\right)$

Remark : The value of g from going up or coming down inside the earth decreases but decreases more in going up than in coming down.

Applications of the variation of g

(i) If a lift or an elevator goes up with any acceleration a, then the man sitting in it experiences a larger weight than that of his original.

Thus, apparent weight = $(mg + ma)$ (increased wt.)

where; m = mass of the man.

(ii) Similarly, if a lift or an elevator comes down with any acceleration a, then the man sitting in it experiences a lesser weight than that of his original.

Thus apparent weight = $(mg - ma)$ (decreased wt.)

(iii) If a lift or an elevator moves with a constant velocity (no acceleration) up or down then there is no change in the weight of the man.

(iv) If during coming downward the rope of the lift or elevator gets broken, then a free falling motion occurs and the sitting man experiences weight lessness.

Since during free falling $a = g$.

Thus apparent wt. $= ma = mg$

$= mg - mg = 0$

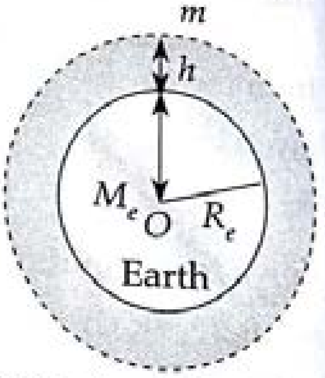
(v) If the value of the acceleration a of the lift or elevator during coming downward became more than g, then the sitting man on the floor of the lift would escape on the roof of the lift.

As if $a > g$ then apparent wt. $= mg - ma < 0 = -ve$

Thus apparent wt.(-ve) physically activates the man upwardly and man comes on the roof of the lift (elevator).

Planets and Satellites : Planets are the celestial bodies revolving around the elliptical orbits of the sun in our solar system. But the heavenly bodies revolving around the planets are called satellites. The Earth is the planet of the sun and the moon is a satellite (natural) of the Earth. The planets and satellites draw their light and energy from the sun because they have no energy of their own. There are so many artificial satellites like—Geostationary satellites, Sputnik-I, Aryabhatta, Rohini and Apple which have been launched in various orbits of the earth. Various communication satellites are orbiting around the Earth.

Sputnik-I was the first artificial satellite launched in 1957 by Russian scientists.



Orbital Velocity : If a body (say, a satellite) revolves around another body (say, the Earth) then the velocity of the revolution of the first body is called orbital velocity.

Let m be the mass of a satellite orbiting around the earth of the mass M_e with velocity v_0 (orbital velocity) and let R_e be the radius of the earth.

Here, gravitational pull on the satellite = Centripetal force necessary to keep the body on the circular track (orbit.)

Thus $$\frac{GM_e m}{(R_e+h)^2} = \frac{mv_0^2}{(R_e+h)}$$

where, h = height of the satellite from the Earth's surface.
and g = acceleration due to gravity on the Earth's surface.

$\Rightarrow$ v_0 = orbital velocity $= \sqrt{\frac{GM_e}{R_e+h}}$

$$\text{Thus; } v_0 = \sqrt{\frac{g R_e^2}{R_e + h}} = R_e \sqrt{\frac{g}{R_e + h}} \qquad \left(\because g = \frac{G M_e}{R_e^2}\right)$$

Now, if $h = 0$, Then v_0 will become the orbital velocity of the earth.

$$\text{Thus } (v_0)_{\text{earth}} = R_e \sqrt{\frac{g}{R_e + 0}} = \sqrt{g R_e}$$

Obviously from the expression of the orbital velocity of the satellite, the value of v_0 doesn't depend upon the mass (m) of the satellite rather it depends on the height (h) of the satellite, and the larger the value of h the lesser would be the value of v_0. But satellites having various masses with the same orbital radius have the same orbital velocity.

The value of orbital velocity of the earth and a geostationary satellite is 7.99 km/sec. (approx. 8 km/sec.)

Period of revolution of a satellite : The time required in which the satellite completes one rotation is called the period of revolution (T).

$$\text{Thus the period of revolution } (T) = \frac{\text{Perimeter of the orbit}}{\text{Orbital velocity}}$$

$$= \frac{2\pi (R_e + h)}{v_0} = \frac{2\pi (R_e + h)\sqrt{R_e + h}}{R_e \sqrt{g}} = \frac{2\pi (R_e + h)^{\frac{3}{2}}}{R_e \sqrt{g}}$$

$$\Rightarrow \quad T = \frac{2\pi (R_e + h)^{\frac{3}{2}}}{R_e \sqrt{g}} \qquad \left(\because v_0 = R_e \sqrt{\frac{g}{R_e + h}}\right)$$

Obviously, the period of revolution (T) of the satellite is independent of the mass of the satellite. Rather it depends on the height of the satellite from the surface, and the more the height (h) the larger the period of revolution (T).

The period of the revolution of the earth or a geostationary satellite is 84 minutes.

Geostationary Satellite : A geostationary satellite is a communication satellite which revolves from west to east and whose period of revolution is 24 hrs equal to that of axial rotation of the earth (earth's spin). Such satellites are stationary and are located at 36,000 km height from the earth's surface. Geostationary satellites (Communication Satellites) transmit signals across larger distances by receiving these signals from one point on earth's surface and reflecting them down to the another point. In order to provide a stationary target for the transmitted signals, these satellites must remain stationary at a point above the earth.

Utilities : (i) The electromagnetic radio-waves are reflected and transmitted and various programmes on the television are displayed.

(ii) It is utilised in radio transmission and telecommunication.

(iii) The Meteorological Department uses it in weather broadcasting and in earlier predictions of the floods and droughts.

Escape Velocity : The escape velocity is the minimum required velocity of a body through which it is projected. It goes beyond the gravitational pull and never comes back.

If m be the mass of a body projected from the earth's surface of radius R_e and mass M_e, the kinetic energy of the body must be equal to the gravitational potential energy.

$$\text{Thus;}\quad \frac{1}{2}mv_e^2 = \frac{GM_e m}{R_e}$$

$$\text{or,}\quad v_e = \sqrt{\frac{2GM_e}{R_e}} \qquad \text{where } v_e = \text{escape velocity}$$

$$\text{But } g = \frac{Gm_e}{R_e^2}$$

$$\Rightarrow \quad v_e = \text{escape velocity} = \sqrt{2gR_e} = 11.2 \text{ km/sec.}$$

This implies that if a body is thrown from the earth's surface with the velocity of 11.2 km/sec, then the body will never come back to the earth.

Here we observe that escape velocity of a body on the earth's surface is

$$v_e = \sqrt{2gR_e}$$

and the orbital velocity of the body around the earth $v_0 = \sqrt{gR_e}$

$$\Rightarrow \quad v_e = \sqrt{2}\,v_0$$

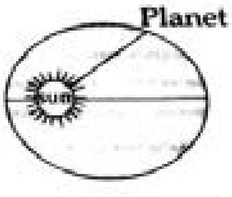
Thus, if the velocity of an orbiting satellite close to the earth is increased $\sqrt{2}$ times or 41%, then the satellite will leave the orbit and will escape. In other words, if the kinetic energy of an orbiting satellite is doubled immediately, then the satellite will escape. The value of escape velocity is maximum on the sun and it is 614 km/sec. That's why even lighter gases like H_2, He etc. do not escape. The moon has the least value of escape velocity i.e. 2.4 km/sec. So, no gases exist on the moon. That's why the moon has no atmosphere and from the surface of the moon the sky appears black. The value of escape velocity of the gaseous molecules must be more than the root mean square (*rms*) velocity for the existence of the atmosphere.

Weightlessness inside the Satellites : In the artificial (man-made) satellite the whole of the gravitational pull provides the necessary centripetal force and no part of the gravitational pull remains unbalanced. Thus a cosmonaut feels weightlessness inside the artificial satellite. That's why a simple pendulum experiment cannot be performed and everything inside the artificial satellite is weightless. Also for the same reason food stuffs of astronaut are supplied in the form of paste. If any cosmonaut tries to drink water from a glass, then he cannot do it because as the glass is inclined water is spread out in the form of droplets.

But on the moon a cosmonaut never feels weightlessness because due to tremendous mass of the moon a gravitational pull is applied ($\frac{1}{6}$th of the earth) and so he or she doesn't feel weightlessness.

The value of acceleration due to the gravity on the moon's surface is $\frac{1}{6}$th of the value of acceleration due to gravity of the earth's surface.

Kepler's Laws of Planetary Motion : Kepler gave three laws regarding motion of the planets around the sun.



- **(i) First law** *(law of elliptical orbits)* : Each planet moves in an elliptical orbit around the sun, the sun being at one of the foci of the ellipse.
- **(ii) Second law** *(laws of areas)*: The radius vector of any planet relative to the sun sweeps out equal areas in equal times, that is the real velocity of the radius vector of the planet is constant.
- **(iii) Third law** *(harmonic laws)*: The square of the period of revolution of any planet around the sun is proportional to the cube of the semi-major axis of the elliptical orbit. i.e. $T^2 \propto a^3$.
  where; a = semi-major axis

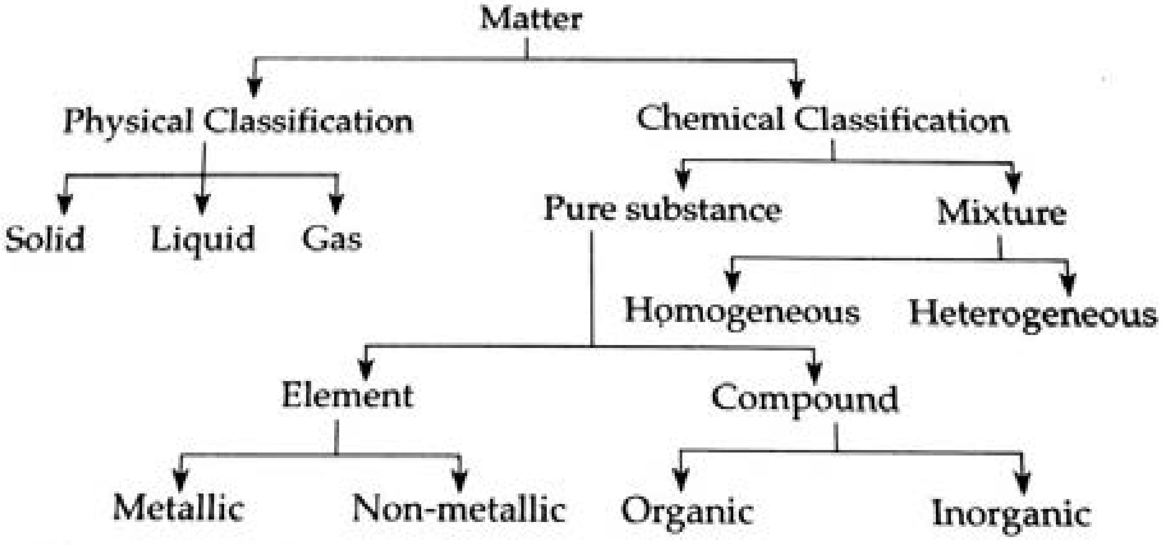
Obviously, those planets which are far away from the sun have a large period of revolution. The planet Mercury which is nearest to the sun has the period of revolution of 88 days while Neptune, which is far away from the sun, has the period of revolution of 165 years.

5. Properties of Matter

Matter : Matter is the substance that occupies space and has mass and it is perceptible to the senses. Matter is one of the two basic components of the physical science in which the another component is being energy. The distinguishing properties of matter are gravitation and inertia. Any entity exhibiting these properties at rest is matter. All material bodies have mass, which is a measure of inertia and every material body near the earth's gravitational field interacts by the virtue of its mass.

Thus two types of masses—inertial mass and gravitational mass remain in existence by their proportion of equality.

The broad classification of the matter is given as below—



The physical classification separates matter into three categories—Solid, liquid and gas-known as three states (phases) of matter. But today plasma, which appears in gaseous or ionized state is actually comes into existence during a thermonuclear process and which is composed of charged particles, is assumed to be the fourth state of matter.

Important characteristics of the Matter

Solids	- Elasticity
Liquids	- Pressure, Floatation, Surface Tension, Capillarity, Viscosity
Gases	- Atmospheric Pressure

(A) ELASTICITY

If a rigid body is in equilibrium under the inter-molecular forces of attraction, whose magnitude depends upon the spacing between the molecules, and an external force is applied, then a new internal force is developed which causes a change in the relative spacing between the molecules. Hence the body changes its shape or size or both and it is said to be *deformed*. When the external force is removed the new internal force brings the body to its normal or original state. The property of the body, by virtue of which it recovers its original shape and size when the external force (deforming force) is removed, is called the *elasticity* of the body.

A perfectly *elastic body* is one that recovers its original size and shape completely when the external force is removed. Thus a *perfectly* plastic body is one that fully maintains its altered size and shape when the external force is removed. Actual bodies behave between these two limits. No body recovers completely its original size and shape after undergoing very large deformations.

A body is said to be rigid if the relative position of its constituent particles doesn't change in equilibrium but on applying an external force a slight relative displacement takes place. In practice no body is perfectly rigid.

Elastic Limit : The maximum limit of the external force (deforming force) by applying on a rigid body, elastic characteristics are maintained, is called *elastic limit*. Different elastic limits are to be found for different bodies.

Strain : When a body suffers a change in its size or shape under the action of external forces, it is said to be *deformed* and the corresponding fractional change is called *strain*. The strain is a ratio and it has no unit, no dimension.

There are three types of strain— longitudinal (linear) strain, volume strain and shearing (shape) strain.

Stress : When external deforming forces act on a body internal forces opposing the former are developed at each section of the body. The magnitude of the internal forces per unit area of the section is called *stress*. In the equilibrium state of a deformed body, the internal forces are equal and opposite to the external forces. Thus, stress is measured by the external forces per unit area of their application. The dimension of the stress is $ML^{-1}T^{-2}$ and its units are N/m^2 (S I) and $dyne/cm^2$ (CGS).

Shear : When external forces are operative tangentially on a body, then a change in shape in the body occurs and it is said to be *sheared*. A shear is numerically equal to the ratio of the displacement of any layer to its distance from the fixed surface.

Hooke's Law : Hooke experimentally observed that within elastic limit stress is proportional to strain, provided the strain is small.

Thus, Stress $\propto$ strain, $\Rightarrow \dfrac{\text{stress}}{\text{strain}}$ = a constant. (Young's modulus)

This is called Hooke's law. The constant of proportionality is called *modulus of elasticity* of the body and depends upon the material of the body and it is different for different types of strain in the same material. Usually there are three types of elasticity— Young's modulus, Bulk modulus and Rigidity modulus.

(i) Young's Modulus : When equal and opposite forces act on a body along only one direction then the change in length per unit length along that direction is called longitudinal or linear strain and the force acting per unit area of cross-section is called longitudinal stress.

Here the ratio of longitudinal stress and longitudinal strain is called Young's modulus of the material of the body.

If L be the length and A be the cross-sectional area and if its length be increased by ΔL when equal and opposite forces F are applied along its length, then

$$\text{Longitudinal Stress} = \frac{F}{A}$$

$$\text{Longitudinal Strain} = \frac{\Delta L}{L}$$

Thus Young's modulus for the material of the body $Y = \dfrac{\frac{F}{A}}{\frac{\Delta L}{L}}$

The unit of Young's modulus is same as that of stress N/m^2(SI) or dyne / cm^2 (CGS).

(ii) Bulk modulus : When a uniform pressure is applied all over the surface of a body then the volume of the body changes. The change in volume per unit volume of the body is called *volume strain* and the applied pressure is called *normal stress*. Thus the ratio of normal stress to volume strain is called *bulk modulus* of the material of the body.

Let V be the volume of a body and let it be diminished by an amount ΔV when the pressure on its surface increases by Δp, then

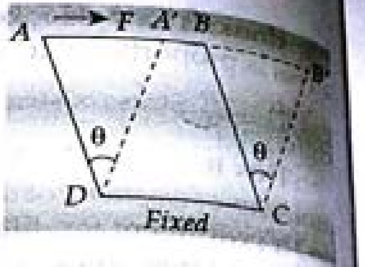
Normal Stress = Δp and Volume strain = $\dfrac{\Delta V}{V}$

Thus Bulk-modulus for the material of the body.

$$K = \frac{-\Delta p}{\frac{\Delta V}{V}} = -\frac{V\Delta p}{\Delta V}$$

The converse of the bulk modulus is called *compressibility*. The negative sign is assigned because volume decreases when the pressure increases.

(iii) Rigidity modulus : When a body is sheared, the ratio of tangential stress to shearing strain is called *rigidity modulus* of the material of the body.

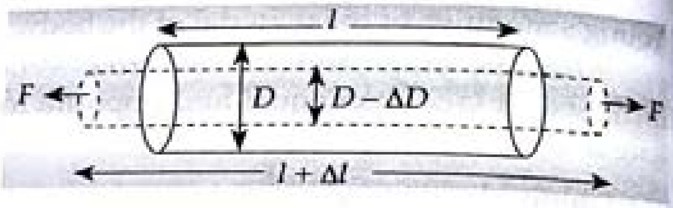


Let $ABCD$ be a section of a cube of face area A. Let its lower face be fixed and the upper face be acted upon by a tangential force F. Let θ be the angle through which its vertical sides have been turned,

then tangential stress $= \frac{F}{A}$

and shearing strain $= \theta$

Thus rigidity modulus of the material of the cube is $(\rho) = \dfrac{\frac{F}{A}}{\theta}$



Poisson's ratio : When two equal and opposite forces are applied to a body along a certain specific direction, the body extends along that direction. At the same time, it also contracts along the perpendicular direction. The fractional change in the direction along which the forces have been applied is called *longitudinal strain*, while the fractional change in a transverse (perpendicular) direction is called *lateral strain*.

The ratio of lateral strain to that of longitudinal strain is called *poisson's ratio*. It is a constant for the material of a body.

If a wire of original length l and diameter D is subjected to equal and opposite force F along its length, then the length of it increases to $l + \Delta l$ and the diameter decreases to $D - \Delta D$,

Now, longitudinal strain $= \frac{\Delta l}{l}$ and lateral strain $= \frac{\Delta D}{D}$

The poisson's ratio (σ) of the material of the wire is $= \dfrac{\frac{\Delta D}{D}}{\frac{\Delta l}{l}}$

The theoretical value of poisson's ratio (σ) lies between -1 to $\frac{1}{2}$. However its practical value is never negative and it lies between 0 and $\frac{1}{2}$.

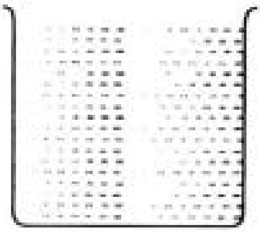
(B) PRESSURE

Pressure is defined as the force applied per unit surface area.

Thus, Pressure $= \dfrac{\text{Force applied}}{\text{Area of the surface}}$

Obviously, the pressure will be more for a larger force and smaller area of the surface and vice-versa. The SI unit of pressure is N/m^2 which is called pascal (pa). It is a scalar quantity.

Pressure applied on liquids : The pressure on the liquid surface is experienced due to its weight exerted everywhere. Usually molecules of a liquid are in a random motion with different speeds in different directions. If a liquid is confined in a container, then the molecules of the liquid collide with each other and also with the walls of the container (vessel). Due to it on the walls of the container and on its bottom (per unit base surface) exerted pressure is applied.



In order to evaluate the pressure exerted on any point of the liquid at height h of the liquid density ρ, the required pressure will be

$$p = \frac{\text{Force due to the wt. of the liquid}}{\text{Area of the surface upto which liquid is confined}}$$

$$= \frac{mg}{A} = \frac{V\rho g}{A} = \frac{Ah\rho g}{A} = \rho g h \qquad (\because \ V = Ah)$$

Where, V = Volume = Area × Height (Length)

g = acceleration due to gravity.

Thus, $p = \rho g h$

Obviously, the liquid pressure is directly proportional to the density of liquid. Also the pressure exerted on the liquid doesn't depend upon the shape or size of the container.

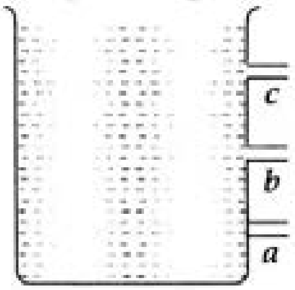
If on the free surface of the liquid atmospheric pressure be operative then the total pressure exerted will be

= Atmospheric Pressure $(P) + \rho g h$

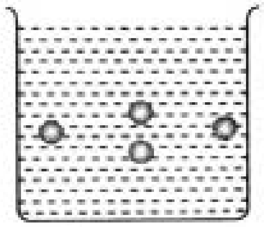
Some observations and conclusions regarding liquid pressure

(i) At any point inside the liquid the pressure exerted by the liquid is directly proportional to its depth from the free surface. Thus, as shown in the diagram the pressure will be in a decreasing order for the points a, b and c.

Thus, $p_a > p_b > p_c$; Where, p_a, p_b and p_c are the respective pressures at the points a, b and c.



(ii) At every point and in every direction the pressure exerted inside the liquid at rest is same. If a number of holes are made after filling the container with liquid, then the liquid will be released from every hole with equal pressure.

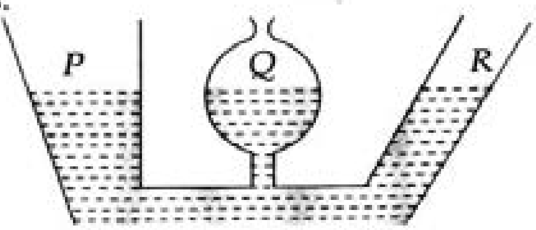


(iii) For the same horizontal surface any liquid at rest exerts the same pressure at all points.

Thus; as shown in the diagram

$p_P = p_Q = p_R$

Where p_P, p_Q and p_R are the respective pressures at P, Q and R.



Pascal's law : This is a natural consequence of the fundamental laws of fluid mechanics and it is called Pascal's law which states that the pressure exerted anywhere in a mass of a confined liquid is transmitted undiminished in all directions throughout the mass so as to act undiminished at right angles to the surface of the vessel exposed to the liquid. According to this law a small force applied somewhere on a confined mass of liquid will appear as a very large force on the wall of the container. This law is directly followed in the working of Hydraulic Press, Hydraulic Brake, Hydraulic Lift etc.

Effect of the pressure on the melting point of the solid and the boiling point of the liquid.

On heating the solid substance if the volume of the substance increases, then by the application of pressure its melting point increases and vice-versa. Examples – wax, sulphur etc. But while on heating the solid substance if the volume of the substance decreases, then by the application of pressure its melting point decreases and vice-versa. Examples — ice, bismuth etc.

The boiling point of a liquid increases on increasing the pressure on the free surface of the liquid.

Example : At simple atmospheric pressure the boiling point of the water is 100°C but if the pressure is doubled then its boiling point becomes 125°C.

(C) FLOATATION

Upthrust or Buoyant force of a liquid : When a body is wholly or partially immersed in a liquid at rest, the liquid exerts pressure on every part of the body's surface which are in contact with the fluid. The pressure is larger on the parts immersed more deeply. So the thrusts exist on all sides in upward direction called buoyancy or buoyant force. The upthrust or the buoyant force acts on the centre of gravity (c.g.) of the displaced liquid by the body which is called *centre of buoyancy.*

Archimedes's Principle : Archimedes's principle states that when a body is partially or fully immersed into a fluid at rest, the fluid exerts an upward force of buoyancy which is equal to the weight of the displaced fluid. Here the apparent weight of the body is equal to the displaced fluid.

Fluids are those substances which can flow, the liquids and the gases both are fluids. Archimedes's principle is valid for both liquids and gases.

Applications :

(a) The relative density of any solid

$$= \frac{\text{wt. of the solid in air}}{\text{Apparent wt. of the solid in water}}$$

(b) The relative density of any liquid

$$= \frac{\text{App. wt. of the solid in the liquid}}{\text{App. wt. of the solid in the water}}$$

The relative density is a pure number and it has no unit.

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

$$\text{Relative density} = \frac{\text{density of the object}}{\text{density of the water at } 4^\circ\text{C}}$$

Note : The density of water is max. at 4°C.

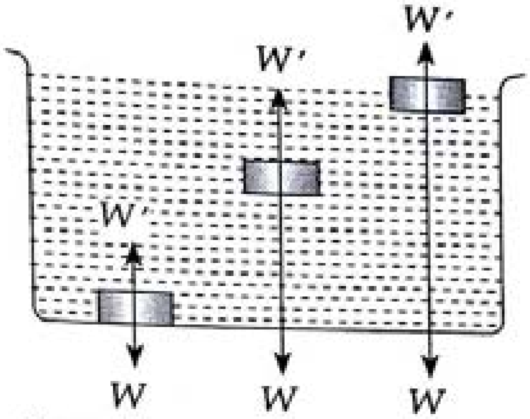
Floatation : If a body tends to sink in a liquid then two forces immediately become operative — the weight (W) of the body downwardly and the upthrust or force of buoyancy (W') upwardly.

Here three cases arise.

(i) If $W > W'$ i.e. the wt. of the body is greater than upthrust, then the body will sink.

(ii) If $W = W'$ i.e. the wt. of the body is equal to the upthrust, then the body floats inside the liquid.

(iii) If $W < W'$ i.e. the wt. of the body is less than upthrust, then the body floats partially in the liquid and the upper part of the body remains outside from the liquid.



(i) $W > W'$ (ii) $W = W'$ (iii) $W < W'$

Also for a body floating partially the ratio of the following must hold

$$\frac{\text{The density of the body}}{\text{The density of the liquid}} = \frac{\text{Total volume of the body inside liquid}}{\text{Total volume of the body}}$$

Application: If a piece of ice floats on a water surface then its $1/10^{th}$ part of the total volume remains above the surface and $9/10^{th}$ part remains submerged. Thus the density of the ice is 0.9 gm/cm³. The density of the pure water 1 g/cm³ or 1000 kg/m³. On the principle of these applications the quantity of water in impure milk is measured by the *Lactometer*.

Hydrometer : The hydrometer is a device through which the relative density of fluids (liquid or gas) is measured.

The law of floatation : When an object floats inside a liquid, then the apparent wt. of the object is equal to the liquid displaced by the object. The centre of gravity (c.g.) of the object and the centre of gravity (c.g.) of the displaced water lie in the same vertical line.

Thus, the wt. of the displaced liquid = Upthrust or force of buoyancy = Apparent wt. of the object

Examples of Archimedes's principle and law of floatation

(i) The ships of iron and the boats of wood float in water but the nails of iron sink. The special design and shape of the ship and the boat through which wt. of displaced water are more than the wt. of the ship and boat, due to which more force of buoyancy becomes operative and the ships or boats float. But the wt. of the water displaced by the nails is less than the wt. of the nails that is why nails sink.

(ii) Life saving belts and submarines operate on these principles.

Meta Centre : The centre of gravity (c.g.) of the displaced liquid by a floating body is called centre of buoyancy. The vertical line drawn from the centre of buoyancy of the displaced liquid intersects the vertical line passing

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through the centre of gravity (c.g.) of the body. This point of intersection is called *metacentre*. A floating body is said to be in a stable equilibrium which has its metacentre higher (above) than its centre of gravity (c.g.)

If in a container (vessel) of water a piece of ice is floating, then after the complete melting of ice, the level of the water in the container is the same as earlier (original.)

Conditions of equilibrium of a floating body

(i) The wt. of the floating body is equal to the wt. of the liquid displaced.

(ii) The c.g. of the body and the c.g. of the displaced liquid (centre of buoyancy) must lie on the same vertical line.

The first condition is required for the translational equilibrium and second for the rotational equilibrium of the body.

Stability of equilibrium : The position of the metacentre relative to the centre of gravity (c.g.) of the body plays a significant role in the stability of the equilibrium of the body. When the metacentre lies above the c.g. of the body, then the body is in stable equilibrium and when the metacentre lies below the centre of gravity (c.g) of the body, then the body is in unstable equilibrium.

(D) SURFACE TENSION

Cohesive force and Adhesive force : The most basic constituents of the matter (substance) are molecules among which intermolecular forces exist. The forces (attractive) operative among these molecules are called *Cohesive force* and it is larger for the solids. That is why it has a definite size. But in liquids the value of cohesive forces is very small and it is negligible for the gases that is why gases diffuse. The forces (attractive) operative among the molecules of two different substances are called *Adhesive force.* Due to adhesive forces water wets the substances and on writing at the Blackboards by the chalk letters become visible. For a solid-liquid pair if the value of adhesive force is greater than the cohesive force among the liquid molecules, then this liquid doesn't wet the solid but if adhesive force is less than the cohesive force of the liquid, then liquid wets solid.

Example : Mercury doesn't wet glass but water wets glass.

Surface Tension : The evidences of the experiments tell us the surface (free surface) of a liquid behaves to some extent like a stretched elastic membrane having a natural tendency to contract and occupy a minimum possible surface area as permitted by the circumstances of the liquid mass. This property of the liquid is called surface tension and it is measured by the force per unit length of line drawn in the liquid surface acting perpendicularly to it and tangentially to the surface of the liquid and tending to pull the surface apart along the line.

$$\text{Thus, Surface Tension } (T) = \frac{\text{Force } (F)}{\text{length of the line drawn liquid } (l)}$$

The surface tension of the all liquids decreases linearly with temperature over the small temperature range.

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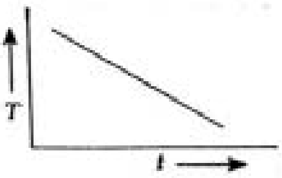


Thus, $T = T_0(1 - \alpha t)$

where, T_0 = value of the surface tension at t °C

α = Temperature coeff.

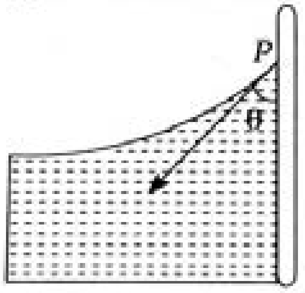
Surface tension is a vector quantity and its SI unit is N / m i.e. Nm^{-1}.

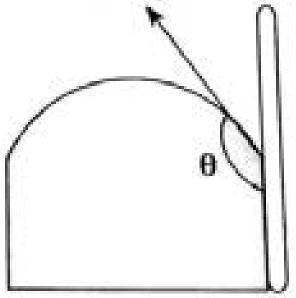
Note : The value of the surface tension becomes zero at the critical temperature.

Surface Energy : Every strained body possesses potential energy. Thus surface of a liquid behaves also like a strained system and hence the surface of the liquid also has a potential energy which is equal to the work done in creating the surface. This energy per unit area of the surface is called surface energy. The surface energy of a liquid is numerically equal to the surface tension. Thus, surface energy and surface tension both can be expressed in Joule / $meter^2$

The free surface of the liquid tries to acquire the minimum area due to surface tension and that's why rain drops, liquid drops, drops of mercury etc. are spherical.

Angle of contact : When a solid body in the form of a tube or a plate is immersed in a liquid, the surface of the liquid near the solid in general is curved (concave or convex). The angle between the tangents of the liquid surface and the solid surface at the point of contact, inside the liquid is called the angle of contact for that pair of solid and liquid.





Pressure Inside a Soap bubble and inside a liquid drop : The pressure inside a soap bubble or a liquid drop must be in excess of the pressure outside the bubble or drop because without such pressure difference, a bubble or a drop cannot remain in a stable equilibrium. Due to surface tension the bubble or drop has a tendency to contract and disappear altogether. To balance the tendency to contract, there must be an excess of pressure inside the bubble or drop.

The excess pressure inside a soap bubble = $\frac{4T}{R}$

Where; T = Surface Tension

R = Radius of the soap bubble

and the excess pressure inside a liquid drop = $\frac{2T}{R}$

Where, T = Surface Tension

R = Radius of the liquid drop

For a soap bubble two surfaces are taken under consideration upon which surface tension is effective, while for a liquid drop and for an air bubble one surface is assumed to be effective for the surface tension.

Some incidents and facts related to surface tension

(i) A thin little needle can float in water due to surface tension.

(ii) Soaps and Detergents reduce the surface tension of the water and clothes are thereby cleaned up.

(iii)Through the soap solution a great bubble can be produced as water reduces its surface tension.

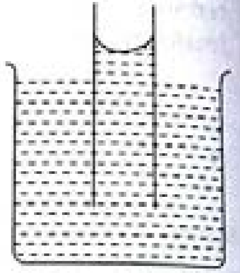
(iv)On a spray of kerosene oil (K-oil) the surface tension of water reduces and mosquitoes sink into the water and die.

(v) Hot soup is tasty (delicious) because its surface tension is reduced and it spreads uniformly on the mouth-tongue.

(vi)The hairs of shaving brush stick to each other due to surface tension on drawing it out from the water.

(E) CAPILLARY ACTION OR CAPILLARITY

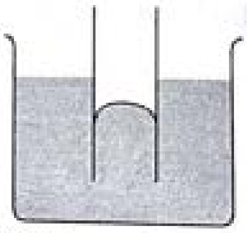
When a long glass tube of very fine bore called capillary tube is dipped into a liquid, then the liquid rises or depresses in the tube. If the angle of contact is acute (less then 90°) then liquid rises and if the angle of contact is obtuse (more than 90°) then the liquid depresses. It is called capillary action or capillarity.



Water rised

Generally the liquid which wets glass rises upwards and the liquid which doesn't wet glass depresses downwards.

When a capillary tube is dipped into water it rises, while in the case of mercury it depresses.



Mercury depressed

Let us suppose r be the radius of a capillary tube, T be the surface tension of the liquid and ρ be its (liquid) density. Let if it rises or depresses h height or depth then the radius of the tube is given as :

$$r = \frac{2T\cos\theta}{h\rho g} \quad \text{or,} \quad h = \frac{2T\cos\theta}{r\rho g} \quad \text{where, } \theta = \text{angle of contact}$$

Obviously; a liquid will rise the most for the least radius and vice-versa.

For pure water and glass $\theta = 0°$

For pure mercury and glass; $\theta = 135°$

If a capillary tube be of height less than h, then the liquid doesn't overflow. The angle made by the liquid surface with the capillary tube changes in such a way that the force $2\pi rT\cos\theta$ becomes adjustable and equalises to the weight of the liquid raised in the capillary tube.

Examples of Capillarity :

(i) Blotting paper sucks to ink due to the small holes (pores) of the paper which act like the capillary tubes.

(ii) Through the wicks of K-oil lamp, K-oil rises into the wick due to capillary action.

(iii) In the branches of plants and leafs the water and nutritional salts are transported through the capillary action.

(iv) In the artificial satellites (in their state of weightlessness) if a capillary tube is dipped into water, then the water will rise upto its full height.

(v) Just after heavy rainfall farmers plough their agriculture lands to break the capillaries form by the soil so that water doesn't come upto upper surface and the soil remains wet (wetted).

(F) VISCOSITY

If the layers of a fluid (liquid or gas) slip or tend to slip on another layers in contact, then any two such layers exert a tangential force on each other. The directions of these forces are such that the relative motion between the layers are opposed. This property of the fluid to oppose relative motion between its layers is called viscosity. The forces between the layers opposing the relative motion between them are called the forces of viscosity. Thus, viscosity may be thought to be an internal friction of the fluid in motion.

Let us suppose a liquid is flowing as shown in the figure (i) and *AB* is the ground level at which the lowermost layer is at rest.

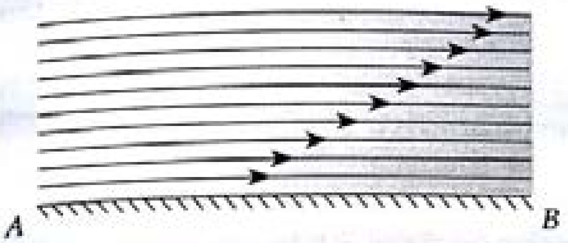


Fig. (i)

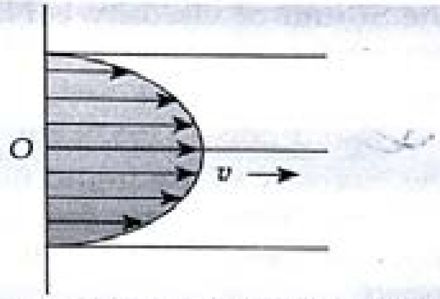


Fig. (ii) : Velocity distribution curve

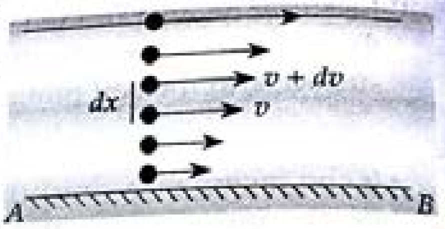
As we move from the lowermost layer to upward the flow velocities of the liquid layers go on increasing and the uppermost layer has maximum velocity. Thus every lower layer has lesser velocity than consecutive upper layers and others. In fact every upper layer tries to drag forward every consecutive (adjacent) lower layer, but a lower layer tries to pull consecutive (adjacent) upper layer backwards.

If a liquid flows in a cylindrical pipe or tube as shown in figure (ii) a velocity distribution curve is obtained which is *parabolic* and the velocity of the mid. Layer is the maximum and decreases for other adjacent layers.

Thus, viscosity is the internal characteristics of liquids and gases which are produced by the cohesive forces of the molecules. When the liquid flows a relative motion among its various layers start due to which the distance among the molecules increases and it is opposed by the cohesive forces and thus viscosity is produced. But in gases viscosity is generated due to molecules transfer from one place to another. That is why, in the gases viscosity is less than that of the liquids. In liquids viscosity is also measured by their concentration. The liquids which are more dense (concentrated) have more viscosity. Examples - Glycerine and Honey have more viscosity than water.

Due to viscosity in air the cloud particles come slowly and clouds seem to be floating.

Coefficient of viscosity : The coefficient of viscosity is the only parameter through which the viscosity of the fluid is measured. Let a liquid be flowing from the ground level and let v be the velocity of layer at a distance x from the bed and $v + dv$ be the velocity at a distance $x + dx$.



Thus, the velocity differs by dv in going through a distance dx perpendicular to it.

Here, $\frac{dv}{dx}$ is called velocity gradient.

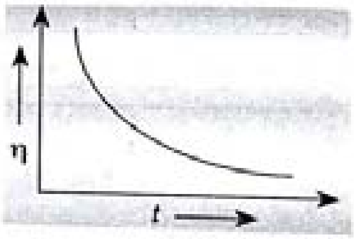
Newton observed that the viscous force acting between any two adjacent layers of the liquid is proportional to the velocity gradient $\left(\frac{dv}{dx}\right)$ in the direction perpendicular to the layers and the area (A) of the layer.

Thus, $F \propto A\frac{dv}{dx} \quad \Rightarrow F = -\eta\, A\, \frac{dv}{dx}$

where; η = a proportionality constant called coeff. of viscosity. Negative sign indicates that the viscous force opposes the relative motion.

The SI unit of viscosity is $N.Sm^{-2}$ and its C.G.S. unit is dyne. Scm^{-2}. However poise is another SI unit of viscosity which has been given in the honour of the French scientist Poiseulle.

Also, 1 poise = $0.1\ N.Sm^{-2}$



The viscosity of the liquid falls very rapidly with rise in temperature. But no actual theory of temp. variation with viscosity has been until developed.

The viscosity of a gas increases with rise in temperature.

Streamline flow or Steady flow : The flow of a fluid is said to be streamlined or steady if the velocity at every point in the fluid remains constant both in magnitude and direction and the energy needed to drive the fluid being used up in overcoming the *viscous drag* between its layers. Thus, in steady flow, each small volume element of the fluid (say a particle of the fluid) follows exactly the same path and has exactly the same velocity as its predecessor.

The line along which the particles of the fluid move one after another, with their constant velocities at various points and their motion are along the tangents to those points, is called a streamline. This also concludes that a streamline is a curve and the tangent to it at any point gives the direction of the fluid-flow at that point.

Turbulent flow : In the flow of another type, the fluid doesn't maintain constancy of the velocity of its fluid particle both in magnitude and direction and this is called turbulent flow. Most of the external energy in maintaining this type of flow is used in setting up eddy–current in the fluid.

Critical Velocity and Reynold's Number : The flow of a liquid remains steady or orderly only till its velocity doesn't exceed a certain limiting value of it which is called its critical velocity. Beyond the critical velocity, the flow loses all its steadiness with the paths and velocities of the liquid change continuously and haphazardly. Such a flow is called turbulent flow and most of the energy needed to drive the liquid is now dissipated in setting up eddies and whirlpools.

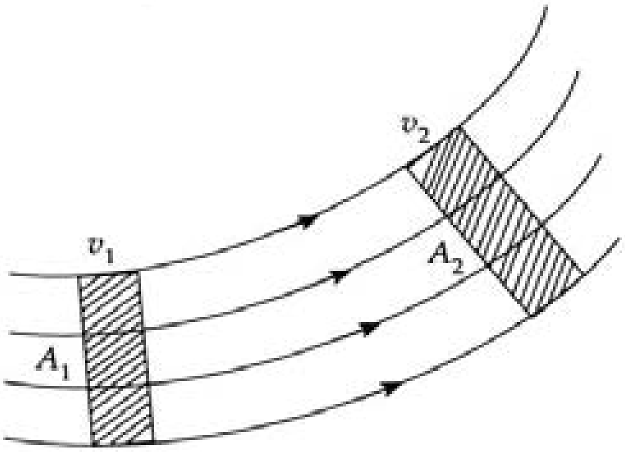
O. Reynolds determined the value of the critical velocity v_c for a liquid as; $v_c = \frac{k\eta}{\rho r}$. Where, η = Coeff. of viscosity

ρ = Density of the liquid
r = Radius of the tube in which liquid is flowing.
k = Reynold's number in which liquid is flowing.

This is called Reynolds formula. Here k is called Reynolds number, its value is very high and usually it is represented on a logarithmic scale. For a narrow tube the value of k is 1000. Obviously for the flow of liquids of higher viscosity and lower density through narrow tubes tends to be steady or orderly (streamlined) whereas that of liquids of lower viscosity and higher density through broader tubes tends to be turbulent.

Principle of Continuity : If an incompressible (const. density), non-viscous, fluid flows steadily through a tube of non-uniform cross-section, then the product of the area of cross-section and the velocity of flow is same at every point in the tube.

Thus, in a particular tube if A be the area of its cross-section and v be the velocity of flow of the liquid at a place (point), then according to the continuity principle; Av = Constant



Thereby, for two different places (points) in a tube as shown in the figure,

$$A_1 v_1 = A_2 v_2$$

Usually the principle of continuity is a fundamental law of fluid-flow and it is a special case of the general physical law of conservation of matter. Also we can conclude that in a steady compressible flow the velocity of flow varies inversely with the cross-sectional area, being larger in narrower parts of the tube and vice-versa.

Bernoulli's Theorem : This states that for all points along a streamline in an incompressible and non-viscous fluid flowing steadily, the sum of pressure energy, potential energy and kinetic energy per unit volume is constant.

Thus, if p be the pressure energy per unit volume, ρ be the density of the fluid, h be the height from the ground level, then by Bernoulli's theorem,

$$p + \frac{1}{2}\rho v^2 + \rho g h = \text{constant.}$$

Here, the term $(p + \rho gh)$ represents the pressure of the fluid even if fluid is at rest, so it is called static pressure of the fluid. The term $\frac{1}{2}\rho v^2$ represents the pressure of the fluid and by virtue of its velocity v it is called dynamic pressure of the fluid.

Thus, Bernoulli's theorem or equation can also be expressed as

Static Pressure + Dynamic Pressure = constant

In fact, *Bernoulli's theorem is nothing* but *the law of conservation of energy for an ideal fluid.*

Applications : (i) Venturimeter : This instrument is based upon Bernoulli's theorem by which the rate of flow (speed) of the liquid (say water) is measured through a pipe.

(ii) Pitot Tube : This instrument (device) is based upon Bernoulli's theorem which measures the rate of flow (speed) of the gas.

(iii) Dynamic Lift : This device operates on the principle of Bernoulli's theorem and in it the force acts on a body such as an air plane wing, a hydrofoil, a spinning ball, the spinning shot of a rifle by virtue of its motion through air.

(iv) Often in a sea if two water boats are moving parallel to each other and come close to each other, then the velocity of the water behind the two boats becomes larger than the individual relative velocities of the boat and consequently low pressure regions develop and the boats collide.

(v) If a Cyclonic storm comes, the roof of the tin foils are flown away because the pressure of the outer surface of the roof has low pressure (high velocity) than that of the air inside the roof in a closed room where no change in the pressure takes place.

Terminal Velocity and Stokes's theorem : When a solid body falls under gravity through a liquid (or gas), the layer of the liquid in contact with the body moves with the velocity of the body, while the liquid confined at the far distance from it is at rest. Thus, the body produces a relative motion between the layers of the liquid. This is opposed by the viscous force appeared between the layers of the liquid. The viscous force increases with the velocity of the body and ultimately becomes equal to the driving force of the body. The body then falls with a constant velocity and it is called *Terminal Velocity.*

Stokes observed dimensionally that when a small sphere moves slowly with a constant velocity through a perfectly homogeneous viscous fluid of an infinite extension, the resistive force experienced by the sphere is $F = 6\pi \eta r v$; where r is the radius of the sphere, v is its terminal velocity and η is the viscosity of the fluid. *This is called stokes law.* If this sphere of density ρ falls freely from rest under gravity through a fluid of density σ and acquires a terminal velocity v, then

$$6\pi \eta r v = \frac{4}{3}\pi r^3 (\rho - \sigma) g. \Rightarrow v = \frac{2}{9}\,\frac{r^2(\rho - \sigma) g}{\eta}$$

where, v = terminal velocity; This concludes that the terminal velocity of a small sphere is proportional to the square of its radius.

(G) ATMOSPHERIC PRESSURE

The gaseous layer which surrounds the earth is called atmosphere. It is held on the earth by the action of gravity. Atmosphere is a mechanical mixture of the gases namely nitrogen and oxygen and some other inert gases. The pressure of these gaseous mixture of atmosphere is called atmospheric pressure. As gravity is the only force acting on the atmosphere, the pressure on the atmosphere is obviously the weight of the vertical column of air of unit cross-section and height equal to that of atmosphere. Firstly the atmospheric pressure was evaluated and measured by Von Guericke. Normally, the atmospheric pressure is the pressure required which is exerted by the column of 76 cm of Hg at 0°C and at 45° latitude near the sea. Thus we can also say that atmospheric pressure is the pressure equivalent to the wt. of the column of 76 cm of Hg for unit cross-sectional area.

Unit of Atmospheric Pressure

Column of 1 cm of Hg = 1.33×10^3 Pascal
1 Pascal = 1 Newton/meter^2
1 Bar = 10^5 Newton/meter^2
1 Millibar = 10^2 Pascal
1 ttor = 1 milli Hg Pressure
= 133.8 Pascal
More appropriately; 1 atmosphere = 1.013×10^5 N/m^2

Thus, the atmosphere exerts on us a pressure of 1600 kg, but we don't realise pressure. The osmotic pressure of the blood and mineral water of our body exerts an equivalent pressure that's why we don't feel external pressure. At the earth's surface (near sea level) on reaching a distance of 110 m upwards, atm. pressure decreases by 1 cm column of *Hg*.

In hilly area it is difficult to prepare food because of a fall in pressure on the hill and the boiling point of water correspondingly rises up. Consequently the latent heat of vaporisation of water decreases too and, that's why the difficulties occur. The phenomenon of ink overflowing from the pen of a man sitting in aircraft at higher altitudes, the phenomenon of bleeding through the nose etc. are common interesting incidents.

Barometer : The barometer is a device by which the atmospheric pressure is measured. Fortin fabricated and designed the barometer on the basis of Torricelli's theorem. It measures the atmospheric pressure accurately and by the help of Fortin barometer weather related activities are predicted. When the indicator of a barometer suddenly falls, it is the indicative prediction of the appearance of a cyclonic storm, but if its indicator falls slowly then the possibility is of the coming of rain and if the indicator inclines upward slowly then there is a possibility of the appearance of a clear day.

Due to large size and some other drawbacks, Fortin barometer was replaced by Aneroid barometer which is compact and convenient and in it no liquid is used. The frequent use of Aneroid barometer is customary to measure the altitude of various places. The device Altimeter operates on the basic principle of Aneroid barometer by which altitudes are measured.

The Standard Atmospheric pressure is the pressure required of 76 cm of *Hg* column or 760 mm of *Hg* column, which is equivalent to 1 atm.

6. Simple Harmonic Motion

Periodic motion and Oscillatory motion : Any motion that repeats in equal intervals of time is called periodic motion. The motion of the earth about its axis is a periodic motion. The motion of the piston of an engine, the motion of a pendulum, the motion of the electron in an atom etc. are the examples of periodic motion. The interval of time after which motion is repeated is called time period (T) or periodicity of the motion. In 1 sec repetition of the motion is called frequency (n). The relation between time-period (T) and frequency (n) is $n = \frac{1}{T}$.

If a particle in periodic motion moves back and forth over the same path, it is called an oscillatory (vibratory) motion. The oscillations of a simple pendulum, sonometer wire, atoms at the lattice sites of a solid, a mass attached to a spring etc. are the examples of periodic motion.

Simple Harmonic Motion : Simple Harmonic Motion (S.H.M.) is defined as motion in which acceleration is always directed towards a fixed point in the path of motion and is proportional to the displacement from that point.

Characteristics of Simple Harmonic Oscillator

(A) If an oscillator executing S.H.M passes through a fixed point (mean position) then

(i) No acceleration exists or acceleration is zero and thereby no force comes into existence and no work is done.

(ii) The potential energy of the oscillator is zero but the kinetic energy is maximum.

(B) If an oscillator executing S.H.M passes through the extreme point (end point) then

(i) The acceleration is maximum and thus acting restoring force will be maximum.

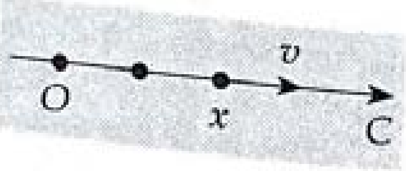
(ii) The oscillator instantaneously comes to rest (its velocity becomes zero) thus kinetic energy becomes zero. But its potential energy is maximum.

Equation of S.H.M. : If a particle of mass m moves in such a way about a fixed point (mean position) O then a force $F = -kx$ acts on the particle where k is a constant and x is the displacement of the particle from the fixed point O.

The acceleration of the particle at any instant is

$$f = \frac{F}{m} = \frac{-k}{m}x = -\omega^2 x \quad \text{... (i)} \quad (\because F = -kx)$$

where, $\omega = \sqrt{\frac{k}{m}}$ (say a constant)



But acceleration $= f = \frac{dv}{dt}$ and velocity $= v = \frac{dx}{dt}$

Thus, acceleration $= f = \frac{d}{dt}\left(\frac{dx}{dt}\right) = \frac{d^2x}{dt^2}$ ... (ii)

Now, from eqns. (i) & (ii)

$\Rightarrow f = \dfrac{d^2x}{dt^2} = -\omega^2 x$. The negative sign is the indication of particle's motion toward the mean position.

$$\Rightarrow \frac{d^2x}{dt^2} + \omega^2 x = 0.$$

This is the eqn. of a simple harmonic oscillator in differential form. The solution of this eqn. is given by $x = a\sin(\omega t + \phi)$.

where, x = instantaneous displacement at time t.
ω = a constant, called angular frequency.
ϕ = phase constant
a = max. displacement or amplitude.

Thus, velocity of the particle executing SHM

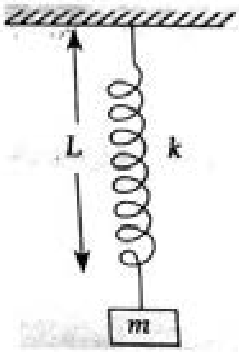
$$v = \frac{dx}{dt} = a\omega\cos(\omega t + \phi)$$

$$= a\omega\sqrt{1-\sin^2(\omega t+\phi)} = a\omega\sqrt{1-\frac{x^2}{a^2}} \qquad \left[\because \frac{x}{a} = \sin(\omega t + \phi)\right]$$

$$= a\omega\frac{\sqrt{a^2-x^2}}{a} = \omega\sqrt{a^2-x^2}$$

$$\Rightarrow \text{velocity} = v = \omega\sqrt{a^2-x^2}$$

Time Period and frequency of a body suspended by a vertical spring : Let L be a natural length of a massless spring and a block of mass m be attached to it and the spring be vertically suspended by a rigid support. Now, let the spring be slightly extended from equilibrium, then the time period of oscillation of the block is given by



$T = 2\pi\sqrt{\dfrac{m}{k}}$. Here; k is called spring constant.

and frequency of oscillation $= n = \dfrac{1}{T} = \dfrac{1}{2\pi}\sqrt{\dfrac{k}{m}}$

If the mass of the spring say m_s is also taken under consideration, then time period of the oscillating body (block).

$$= T = 2\pi\sqrt{\frac{m+\frac{m_s}{3}}{k}} \text{ and frequency of oscillation}$$

$$= n = \frac{1}{T} = \frac{1}{2\pi}\sqrt{\frac{k}{m+\frac{m_s}{3}}}$$

If a spring of length L and spring constant k be cut (or divided by breaking) into two equal parts or pieces each of length $L/2$ and spring constants k_1 and k_2, then $k_1 = k_2 = 2k$.

Thus, $k = \dfrac{k_1}{2} = \dfrac{k_2}{2}$

If n be the frequency of oscillation of a body of mass m attached to a massless spring, then frequency of oscillation $(n) = \dfrac{1}{2\pi}\sqrt{\dfrac{k}{m}}$

But if the spring is cut into two equal pieces then each attached with a body of mass m will oscillate with frequency $(n') = \sqrt{2}\,\frac{1}{2\pi}\sqrt{\frac{k}{m}}$

$$\Rightarrow n' = \sqrt{2}\,n$$

In SI unit frequency of the oscillator is expressed in Hertz (Hz). Here angular frequency of a simple harmonic oscillator (ω) is related to frequency of n as $\omega = 2n$, but $n = \frac{1}{T}$,

Thus, $\omega = \frac{2\pi}{T}$,

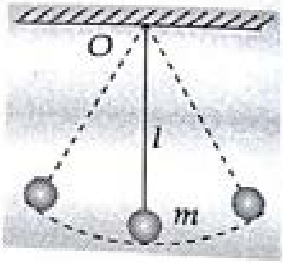
where T = Time period of the oscillator measured in seconds.

The maximum displacement of the oscillator (or particle) from the centre of oscillation (mean position) is called amplitude of the oscillation.

If a smooth straight tunnel is made diametrically opposite the points on the surface of the earth, then a body dropped to it executes S.H.M. and its period of oscillation is 84.2 minutes.

Simple pendulum and Some interesting incidents related to it :

A simple pendulum consists of a heavy particle suspended by a massless inextensible and perfectly flexible string (thread). The distance between the point of support (O) and the particle (bob) is called length (l) of the pendulum. An ideal simple pendulum defined as above can never be realised in practice, though in laboratories a small brass ball (bob) is suspended by a long thin cotton thread to construct a simple pendulum. The distance between the point of support and the centre of gravity of the bob is called the effective length of the pendulum.



The time period of the simple pendulum = $T = 2\pi\sqrt{\frac{l}{g}}$

(A) Obviously $T \propto \sqrt{l}$ i.e. on increasing the length of the pendulum the time period T will increase and vice-versa. For example when a girl be stand up during springing then the center of gravity (c.g.) of the body of the girl comes upward and the effective length is decreased smaller consequently the time period of the oscillation of the spring becomes small or lesser than that of initial value.

Also the time period of a simple pendulum doesn't depend upon its mass, so if another girl comes and seat gently then its time period doesn't change.

(B) As $T \propto \sqrt{\frac{l}{g}}$ and the value of g decreases either in going up or coming down inside the earth's atmosphere so a pendulum clock will become slowed down and will indicate a longer time period.

(C) If a pendulum clock is brought inside an artificial satellite, then due to the state of weightlessness inside the satellite ($g = 0$), the time period of the clock becomes infinite (∞). That's why such clock doesn't work inside the artificial satellites.

(D) In summer season the effective length of the pendulum clock is lengthened (increased length), so its time period is also increased and consequently the clock becomes slow. But in winter season the effective length is contracted thus time period is decreased and the clock becomes fast.

(E) As on the moon the value of acceleration due to gravity is $g/6$, where g is acceleration due to gravity on the earth's surface. Thus, the period of oscillation of the pendulum clock is increased on the moon's surface and so it (pendulum clock) is slowed down.

II. Sound (Acoustics)

1. Wave Motion

Wave motion : A wave motion is a process of transmission of disturbances created somewhere in an elastic medium in all directions around it and along with the disturbances energy transmits. Although the particles of the medium only vibrate about their mean position and do not leave their original respective positions.

Thus, three conditions are required for the formation of a wave—

(i) A vibrating body called the *source* is necessary to create the disturbance.

(ii) An elastic medium called the propagating medium through which the wave transmits.

(iii) Particles of the medium which take part in the process of onward transmission of the *disturbance* by executing successive similar vibrations in the source about their respective mean position.

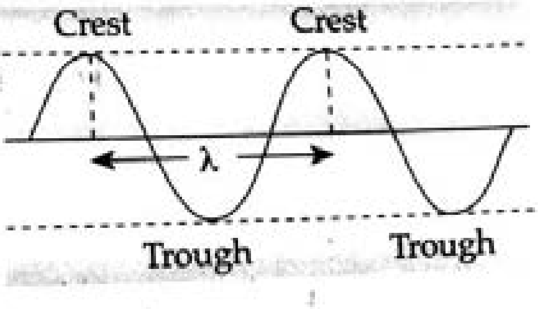
Such wave (disturbance) progression along with energy transmission is called a wave-motion.

Broadly a wave is categorized into two types—

(i) Mechanical waves (Elastic waves)

(ii) Non-mechanical waves (Electromagnetic waves).

(i) Mechanical waves *(Elastic waves)* **:** Waves which propagate in materialistic elastic medium like solid, liquid or gas are called mechanical waves. There are two essential features— elasticity and inertia for the existence of the mechanical waves.



Types of Mechanical waves :

(a) Transverse mechanical wave

(b) Longitudinal mechanical waves.

(a) Transverse mechanical wave : If in an elastic medium wave propagates (transmits) along the perpendicular direction of the particles vibration, then the wave is called transverse mechanical wave.

Transverse mechanical wave can be generated in solids and upper surfaces of the liquids. But it cannot be generated through gases and inside liquids due to lack of rigidity. The transverse wave propagates in the form of crest (max. upwards displacement) and trough (max. downwards displacement). The distance between two adjacent crests or troughs is called wavelength and it is represented by λ.

(b) Longitudinal mechanical wave : If in an elastic medium, a wave propagates (transmits) along the direction of particles vibration, then the wave is called longitudinal mechanical wave.

Longitudinal wave can be generated (produced) in all medium— solids, liquids and gases and such wave transmit through compression and rarefaction. In compression the pressure and the density of the medium is maximum, while in rarefaction the pressure and the density of the medium is minimum. Examples — Sound waves in air, earthquake waves, water waves etc. are longitudinal mechanical waves.

(ii) Non-mechanical waves (Electromagnetic waves) : Waves whose propagation (transmission) does not need any elastic medium and which is generated by the mutual oscillations of electric and magnetic fields perpendicular to each other. Such waves are called non-mechanical waves (electromagnetic waves). The electromagnetic waves propagate in a perpendicular direction to each electric field and magnetic field and it travels in vacuum with velocity of light $c = 3 \times 10^8$ m/s or 3 lakh km/sec. Each and every electromagnetic wave travels with the same velocity i.e. velocity of light *c*. The wavelength range of various electromagnetic waves lie between 10^{-14} meter to 10^{-4} meter. The examples of electromagnetic waves are radio waves, ultra violet rays, X-rays, γ-rays, thermal radiations etc.

In the early days light was also assumed to be an elastic wave and a hypothetical medium called ether was supposed to be its medium of propagation. But later after the negative result of ether drag by Michelson-Morely experiment, this concept was discarded (abandoned).

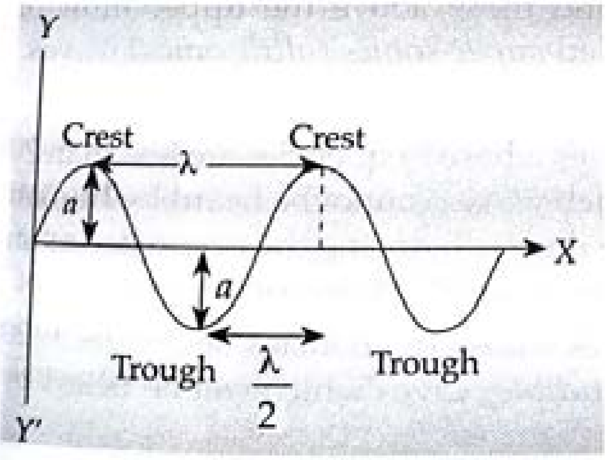
Spectrum of electromagnetic waves

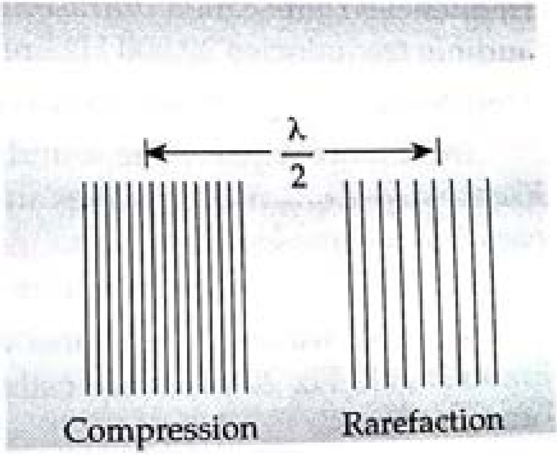
Electro-magnetic waves	Inventors	Wavelength range (m)	Frequency range (Hz)	Utilities
X-rays	Roentgen	10^{-10} m to 10^{-8} m (1A°–100A°)	10^{18} Hz to 10^{16} Hz	X-rays are extensively used in various surgical diagnosis like bone fractures, diseases of lungs, kidneys etc. and in various industrial purposes.

(1A° = 10^{-10} meter)

Electro-magnetic waves	Inventors	Wavelength range (m)	Frequency range (Hz)	Utilities
γ-rays	H.Becquerl	10^{-14} m to 10^{-10} m ([illegible]Å°–1Å°) [0.0001Å°	10^{20} Hz to 10^{18} Hz	γ-rays have max. penetrating power which is utilized in nuclear reaction and artificial radioactivity.
U/V-rays	Ritter	10^{-8}m to 10^{-7}m [[illegible]Å°– 1000Å°)	10^{16}Hz to 10^{14}Hz	U/V rays are used in producing electric discharge, photoelectric effect and in destroying bacteria.
Visible radiation	Newton	3.9×10^{-7}m to 7.8×10^{-7}m	10^{14} Hz to 10^{12} Hz	By visible radiation objects become visible and by the illumination of the visible radiation objects are made distinctive.
Infra-red radiation	Hurssel	7.8×10^{-7}m to 10^{-3}m	10^{12} Hz to 10^{10}Hz	*I/R*–radiations are thermal radiations and on which object these incident raise the temperature. These are utilized in photography of the objects behind mist and fog. It is also used to warm patients in hospitals. In T.V. remote *I/R* is used.
Shortradio waves	Henric Hertz	10^{-3}m to 1 m	10^{10}Hz to 10^{8}Hz	Short radio waves are used in radio, T.V. and Telephone etc.
Long radio waves	Marconi	1 m to 10^{4}m	10^{6}Hz to 10^{4}Hz	Longer radio waves are used in radio and T.V.

Terms related to wave motion





(i) Amplitude : The maximum displacement from the mean position of the vibration of the particles of the medium is called amplitude of the wave. Thus, maximum displacement on both sides from the equilibrium position is called amplitude which is represented by a.

(ii) Time-period : The time taken by the vibration of the particles of the medium in completing one oscillation is called time-period (T)

(iii) Frequency : The number of oscillations executed by the particles of the medium in one second is called frequency (n) of the wave and in SI unit it is expressed in hertz (Hz).

Thus; $n = \frac{1}{T}$

(iv) Phase : The state of motion of a particle of the medium at a given point of time is called phase of the wave. The state of motion of a particle at a time means where it is and what is its direction of motion at that instant ?

(v) Wavelength : The distance required to cover one complete oscillation of any particle of the medium is called wavelength (λ). In a transverse wave the distance between two consecutive (adjacent) crests or troughs is called its wavelength (λ) and in longitudinal wave it is the distance between two consecutive (adjacent) compressions or rarefactions

(vi) Wave speed : The rate of the distance travelled by the wave (disturbance) is called wave speed (v).

The relation among wave speed (v), wavelength (λ) and frequency (n) is

Wave speed (v) = frequency (n) × wavelength (λ).

2. Sound Wave

The sound wave is a longitudinal mechanical wave which is generated (produced) by the transmission of the disturbances in the form of compressions and rarefactions. This train of packets of compressions and rarefactions on reaching the listener's ears produces a variations of pressure on his or her ear-membranes. These pressure variations set up impulses on the auditory nerves which carry the message to the hearing centre of the brain.

In fact sound is produced by the rapid vibration of material bodies and its sensation is produced by a vibrating body, provided its frequency of vibration lies within the range 20 Hz to 20,000 Hz called audibility limit (range). The frequencies of less than 20 Hz (lower limit of audible frequencies) are called *infrasonics* and those above the upper limit of audible frequencies 20,000 Hz are called *super-sonics (ultrasonics) waves.*

Frequencies range of sound waves :

Infrasonic waves : The sound waves whose frequencies are less than 20 Hz are called *Infrasonic waves* and such waves cannot be heard by human ears. Such waves are produced inside the earth during the occurence of an earthquake. Heart beats of a human body are also infrasonics.

Audible waves : The sound waves whose frequencies lie between (20 Hz to 20,000 Hz 20 kHz) are called *audible waves* which can be heard by human ears.

Ultrasonic (Supersonic) waves : The sound waves whose frequencies are more than 20,000 Hz are called ultrasonic waves and such waves cannot be heard by human ears. Ultrasonics were produced firstly by Galton and later these were produced in certain crystals of tourmaline, quartz, zinc oxide, etc. by Piezo electric method. Thus, Piezo electric crystals of quartz, rochelle salt, tourmaline etc. are generators of ultrasonics. As the frequencies of ultrasonics are too large so these waves are very energetic and have shorter wavelengths. Some animals like birds, bats, cats, dolphins etc. not only hear ultrasonics but also generate them. In the dark, the bats can fly freely without dashing against any obstacle (barrier) because during their course of flight they constantly send forward ultrasonic signals and if any obstacle is there, they hear the echoes (reflected sound wave) of the ultrasonics and at once change their course of flight. Bats can easily hear the ultrasonics of the frequencies of 1,00,000 Hz.

Utilities :

(i) In medical science ultrasonics are used in bloodless surgical operations, in detection of tumor and teeth cavity etc. By ultrasonic radiation various neurological disease and arthritis are being cured.

(ii) In western countries milk is purified by passing contaminated milk through ultrasonics. Generally contaminated (impure) milk has bacteria which are destroyed on passing through the ultrasonics.

(iii) Ultrasonics coagulate the dust particles in winter season. Thus mists and fogs at the airports are diminished and this facilitates in landing aircrafts (aeroplanes).

(iv) Ultrasonics are also used in measuring the sea depth, and in detecting or locating larger rocks, icebergs, bigger fishes etc. inside the sea. SONAR (Sound Navigation And Ranging) is a technique through which objects located inside the sea are detected.

3. Speed of Sound

For the propagation of sound wave (mechanical longitudinal wave) a materialistic medium is needed. That's why sound doesn't propagate in vacuum. The speed of sound is different in different media. Newton firstly theoretically observed and propounded that the speed of sound is dependent on elasticity (E) of medium and its density (d) as given below;

$$v = \sqrt{\frac{E}{d}}$$

If the medium is solid then elasticity (E) = Young's modulus (γ)

$$\text{then } v = \sqrt{\frac{\gamma}{d}} \text{ (solid)}$$

Newton assumed (considered) that if sound wave propagates through a gaseous medium, then the disturbances transfer in the form of compressions and rarefactions in such a way that the temperature remains constant and the process is said to be isothermal.

Thus, elasticity (E) = Bulk's modulus (β)

$$= \text{Pressure } (p)$$

$$\Rightarrow \quad v = \sqrt{\frac{p}{d}} \text{ (gas)} = 280 \text{ m/sec}$$

where, $p = 1.013 \times 10^5 \text{ N.m}^{-2}$,

$d = 1.29 \text{ kg.m}^{-3}$.

But this calculated value (280 m/sec) of the speed of sound by Newton himself was less than the actual value of the speed of sound (= 332 m/sec) which was globally acceptable.

Thus, a corrective modification was made by Laplace in this regard and he asserted that during the transmission of sound wave the compressions and rarefactions transfer so rapidly that temperature doesn't remain constant but the total thermal energy remains constant. Thereby Laplace assumed that the process of sound wave transmission is adiabatic (const. thermal energy) not isothermal (const. temperature) and it is called Laplace's correction.

Thus, elasticity (E) = Bulk's modulus $(\beta) = \gamma p$

$$\text{where,} \quad \gamma = \frac{C_p}{C_V} = \frac{\text{molar sp. heat at constant pressure}}{\text{molar sp. heat at constant volume}}$$

$$= 1.44 \text{ (for air diatomic gas)}$$

$$\text{Thus, speed of sound} = v = \sqrt{\frac{\gamma p}{d}} = 332 \text{ m/sec.}$$

As the speed of light in air (c) is 3×10^8 m/s (300000 km/sec) which is very large than the speed of sound (332 m/sec). That's why during lightning in the sky both light and sound originate at the same time but light appears earlier to the eye and sound comes later to the ear.

Liquids are more elastic than gases but solids are the most elastic. Thus, speed of the sound is maximum in solids. Also speed of sound is more in liquids than gases. The speed of sound in air = 332 m/s

in water = 1493 m/s

and in iron = 5130 m/s

Speeds of sound in various media

Medium	**Speed of sound in *m/s* at 0°C**	**Medium**	**Speed of sound in *m/s* at 0°C**
CO_2	260	Water	1493
Air	332	Sea water	1533
Vapour (100°)	405	Iron	5130
Alcohol	1213	Glass	5640
Hydrogen	1269	Aluminium	6420
Mercury	1450		

If a sound wave propagates from one medium to another, then its speed and its wavelength changes but its frequency remains constant. Thus, the speed of sound doesn't depend on frequency. On moon no sound wave exists because of the absence of atmosphere (medium).

Variation in the speed of sound

Effect of pressure : At the same temperature the speed of sound in gas doesn't vary with pressure.

Effect of temperature : The speed of sound is directly proportional to the square root of its absolute temperature i.e. $v \propto \sqrt{T}$.

More appropriately as at 0°C the speed of sound is 332 m/sec and if at t°C speed be v_t then $v_t = 332 + 0.61t$. Obviously, for every 1°C increase in temperature the speed of sound increases by 0.61 m/sec.

Effect of humidity : The density of dry air is more than that of moist air. Thus, in moist air value of the speed of sound is more than in dry air. This is the reason why in rainy season the siren of the train is heard sharply up to a far distance than in summer season.

Effect of the speed of the medium : If the medium is speeded up then the speed of sound increases in the same direction and decreases in the opposite direction.

4. Characteristics of musical sound

Musical notes differ from each other in the respect of at least one of the three properties, namely– Intensity, Pitch and Quality. These three are called characteristics of a musical sound. A musical sound is bound to differ from another musical sound in at least one of these three properties and hence they provide a means to distinguish one musical note from another.

Intensity and Loudness : The intensity of a musical sound is defined as the rate of flow of energy per unit area of a plane perpendicular to the direction of wave propagation. The SI unit of intensity is Joule/sec-meter^2 or watt/meter^2.

The intensity of a simple harmonic wave is given by

$$I = 2\pi^2\nu^2a^2\rho v.$$

where;
a = amplitude of the wave
ρ = density of the medium
ν = frequency of the wave
v = wave speed

Obviously, the intensity of the musical sound is proportional to the square of the amplitude of the wave, the density of the medium, the square of the frequency of the wave, and wave speed. Apart from these the intensity of the musical sound varies inversely as the square distance of the source and varies directly to the elasticity of the medium. This intensity also depends on the size of the source and a larger source has larger intensity and vice-versa.

In fact intensity is a special feature (characteristic) of the musical sound by which feeble (weak) and loud (sharp) sounds can be identified. Though the absolute unit of intensity is watt/m^2 but it has no significance and another arbitrary unit is *bel* which is expressed on the logarithmic scale and it is used frequently to measure the relative intensity. This unit bel was a nobel honour to the inventor of the telephone *Graham Bel*. Generally, $\frac{1}{10}th$ of bel which is called *decibel* (db) is the most practical unit of the relative intensity.

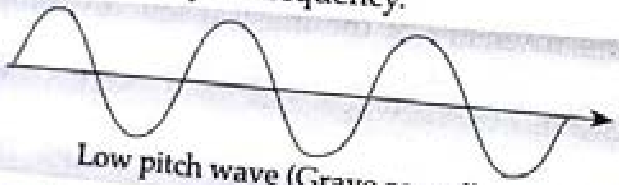
Thus, relative intensity of first relative to second on the logrithmic scale is expressed as 10 $\log_{10} \frac{I_1}{I_2}$ decibel (db). The standard intensity level selected for expressing the relative intensity is 10^{-12} w/m^2.

Loudness is the sensation produced in the human ears and it is something that is not absolute and it varies from person to person although loudness depends upon the intensity. Thus intensity is the physical cause of the loudness. The unit of loudness is phon which is assumed to be the counterpart of the decibel (db).

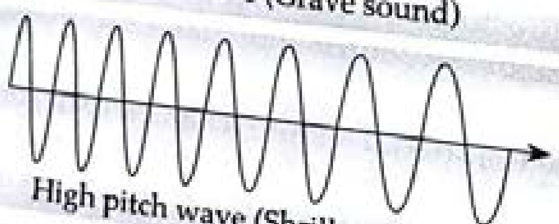
Source of sound	**Intensity (db)**	**Source of sound**	**Intensity (db)**
Whisper	15-20	Press	100-105
Ordinary conversation	40-60	Archestra	100-110
Loud speaker	70-80	Rocket	160-170
Hot discussion	70-80	Missile	180-190
Heavy motor vehicle, motor bike	90-95	Siren	190-200

For a sound sleeping man, 50 db sound is sufficient to wake him up. To dwell in the noise of 80 db is harmful and 90 db sound has its maximum limit to dare and if such noise be continued everyday 10 hours then the man would become deaf. World Health Organisation (WHO) has recommended 45 db sound good for the human ears, the sound of more than 75 db is assumed to be dangerous and the sound of 150 db can make human beings abnormal (mad).

Pitch and Frequency : The pitch of a musical note is that physical cause which distinguishes a shrill note from a grave note of the same intensity and coming from the same instrument. Thus the degree of shrillness of a musical note is its pitch. The pitch of a note emitted by a source depends upon its frequency of vibration. The greater the frequency of vibration of a source, higher the pitch of the note emitted and vice-versa. That's why the pitch of a note is expressed by its frequency.



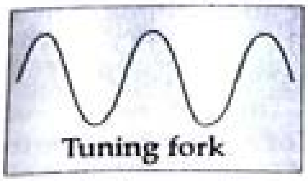
Low pitch wave (Grave sound)

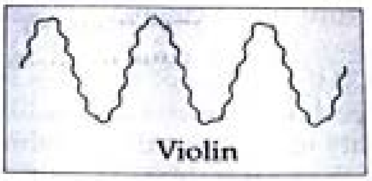


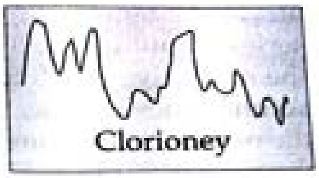
High pitch wave (Shrill sound)

Children and women have shrill voice sound due to higher value of pitch but the grave sound of the man is due to low pitch. The horrified voice of lions have lesser pitch than that of mosquitoes. This shows that grave and shrill sounds are indicators of low and high pitches which has been displayed in the above diagram (graphical representation).

Quality or Timber : Quality or timber is a third feature of a musical note which distinguishes between two notes of the same intensity and pitch but produces two different musical instruments. The quality or timber of a note is appeared due to presence of different harmonics. The presence of harmonics affect the form of the wave emitted by the musical instrument.







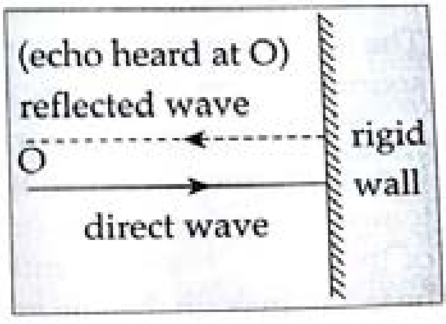
The harmonics present do not affect the frequency of the fundamental tone, but they simply reshape the form of the fundamental wave as shown in the diagram. On account of the different shaping of the wave form by the harmonics, the quality of different notes becomes different. Due to the difference in the quality we identify and detect the voices of well known persons.

5. Properties of sound wave and some acoustical applications.

(i) Reflection of sound wave : Like light wave, sound wave also returns to its original medium after incidence on any rigid surface and it is called reflection of sound wave. When reflection takes place from a rigid wall there is no change in the nature of the wave i.e. compression remains compression and rarefaction remains rarefaction. But when the reflection takes place on the open end of a pipe (organ pipe), then the nature of the wave changes i.e. compression changes into rarefaction and vice-versa. Due to a longer wavelength the sound wave reflects at large surface than light wave. In our daily life there are so many examples of sound wave reflection like reflected sound from walls, mountains, rivers, vallies etc.

(a) Echo : Echo is a natural phenomenon of reflection of sound and it is simply the repetition of a sound wave produced by the reflection from an obstacle like rigid wall, tower or mountain. The essential conditions for the formation of an echo is that the interval between the arrivals of the direct wave and the reflected wave must be at least $\frac{1}{10}$th of a second (0.1 sec) because a human ear cannot distinguish between two sounds arriving within $\frac{1}{10}$th of a second. Thus the minimum distance to hear (listen) an echo distinctly would be 16.6m (approx. 17m). Since speed of sound (v) = 332 ms^{-1} in air at NTP, time interval (t) = 0.1 sec.

$$\Rightarrow \text{required distance } (x) = \frac{vt}{2} = \frac{332 \times 0.1}{2}$$
$$= 16.6\text{m}$$



With the help of echo the depth of sea, the depth of wells, the altitudes of flying aircrafts etc. are measured. With the help of SONAR (Sound Navigation And Ranging) and producing (by the use of) ultrasonics we measure the sea-depth.

No mechanical wave can be produced on the moon due to the absence of the atmosphere. Also due to lack of an elastic medium, sound (longitudinal mechanical wave) cannot be produced. Thus no echo (reflected sound wave) can exist (be produced) on the moon.

(b) Reverberation : When the programmes of music, speech or concerts etc. are organized in lecture halls, cinema houses or auditoriums then a series of multiple reflections takes place from the walls, roofs and floors of the respective buildings. If the source of sound is stopped then up to a few seconds these music, speech or concerts are audible. This continuation of the original sound intensity level above the threshold of audibility is due to the multiple reflection of the source. Here, if source of sound is cut off then it is called reverberation and the time up to which this sound is sustained is called the time of reverberation.

The time of reverberation depends on various factors like material of the absorber, area of the absorbing material, volume of the building (like lecture hall, auditorium) etc.

Here, for the evaluation of reverberation time, Sabine gave a law as

$$T = 0.171\,\frac{V}{A} = 0.171\,\frac{V}{as}$$ (SI unit), called Sabine's law.

where, V = volume of the hall

and, $A = as$

where, a = absorption coeff.

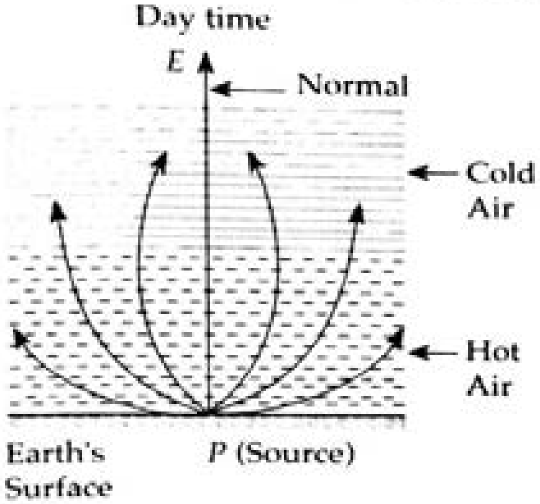
s = area of the absorbing material.

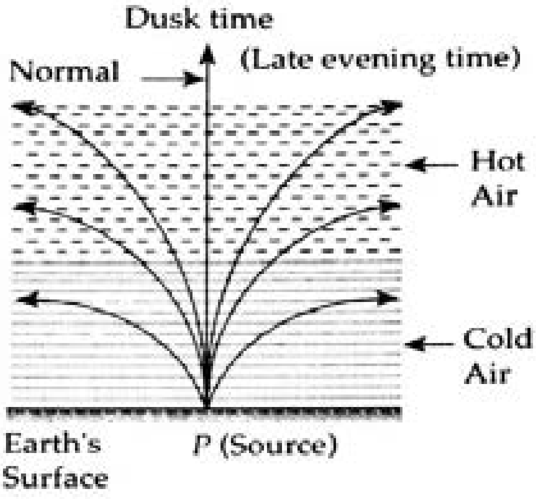
Thus, time of reverberation can be balanced (accommodated) by increasing or decreasing the area of the absorbing material. To sustain the reverberation in the lecture hall or auditorium the walls are made rough or they are covered by porous screens through which some sound is absorbed and original sound becomes clearly (distinctively) audible. The carpet of the floor is also utilised as sound absorber. Due to the reflection of sound *thunder in the cloud* appears.

The fitness of lecture halls, cinema houses, auditorium etc. for music, speech, concerts etc. depends largely on their design and construction. If the construction is such that there is uniformity in rendering of speeches, music, concerts etc. then these are said to be acoustically good, but if not they are said to be acoustically bad. There are two chief parameters echos and reverberation for the bad acoustics of the buildings.

(ii) Refraction of Sound : When a sound wave moves from one mechanical (elastic) medium to another mechanical (elastic) medium, the wave is refracted or transmitted. This phenomenon is called refraction and the refracted wave is deviated from the original path of the incident wave. The main reason for occurrence of refraction in sound is different speeds of sound in different medium at different temperatures.

The best example of refraction of sound or a natural consequence of acoustic (sound) refraction is the appearance of temperature gradient (variation of temperature due to variation of depth in different medium) near the surface of the earth. It is frequently observed that human voices are more clearly heard at dusk (in the late evening) than during day time. In the day time, the temperature of air is maximum near the ground surface and it diminishes upwards. Thus, the speed of sound is the largest near the surface of the earth ($v \propto \sqrt{T}$) and decreases upwards. So a ray of sound diverging upwards from a source on (or near) the earth's surface is refracted continuously towards the normal and hence less sound reaches the observer. At dusk the situation is just the opposite. Now, a ray diverging upwards from a source on (or near) the surface of the earth is refracted continuously away from the normal. Now, it is totally reflected when it begins to travel downwards with a continuous refraction to reach the observer towards vertically.





(iii) Free Vibration : When a body, which is capable of vibrating is displaced from its position of rest and then is left to vibrate itself, it will vibrate with its own time period or frequency. Such vibrations of the body are called its free vibrations, provided it is free from all type of resisting force, external or internal. Example - the prong of a tuning fork, the stretched string of a sonometer etc. are vibrations capable bodies. When these bodies are disturbed from their position of rest they vibrate and these vibrations are said to be free vibrations, and these are not resisted by frictional forces such as air resistance, viscosity or any other frictional forces etc.

Though vibrations of such bodies are free from the external forces namely air resistance, they are not free from internal frictional forces namely viscous force. In the course of vibrations, the different layers of the prong move relatively to one another and due to this relative motion between the layers a force comes into play which tries to diminish the relative motion. This force is called viscous force or internal frictional force. In practice vibrations of a body are resisted by some kind of frictional force and hence resisted vibrations are the natural vibrations. The frequency of free vibrations of a body is called its natural frequency.

(iv) Forced vibrations : Resonance : If a body can vibrate freely then due to resisting forces the natural frequency of the body starts to decay and thus an external periodic force is needed. A tussle starts between the frequency of the external force and the natural frequency of the body and ultimately the frequency of the external periodic force predominates and through this frequency the body vibrates which is called forced vibration.

But a unique situation arises when the frequency of the external periodic force becomes equal to the natural frequency of body of the free vibration. This is called *resonance*. Thus at resonance natural frequency of the body is equal to the frequency of the external periodic force.

Example : In 1939 Takoma bridge of USA was destroyed due to a mechanical resonance. The fast moving air confined to the outer surface across of the bridge had the same frequency as that of natural frequency of the bridge, consequently the phenomenon of resonance occurred. When military men move across any bridge in troops, then under precautionary measure the condition of resonance is said be avoided by walking troops in such a way that their feet do not fall in the same order.

A transistor (radio) is also tuned (switched on) by means of resonance. The frequency or wavelength of a particular radio station is made adjustable and a particular frequency is tuned by the same frequency on the antena.

(v) Superposition of waves : From a physical point of view it is necessary that when two or more than two waves meet in a medium a resultant wave must be formed. The basic necessity is called superposition principle of waves. The principle states that the resultant displacement due to a number of waves at any point in a medium is the vector sum of the displacements produced by the component waves. If $\vec{y}_1, \vec{y}_2, \vec{y}_3, \ldots$ be the instantaneous displacements produced by the component waves at a given point (place), then the resultant displacement (wave) at the same point by the superposition principle will be given by

$$\vec{y} = \vec{y}_1 + \vec{y}_2 + \vec{y}_3 + \ldots\ldots\ldots$$

In sound (acoustic) interference, beats and stationary waves are the direct outcome of this principle.

(a) Interference in Sound : Interference is the phenomenon of sustained cancellation or reinforcement of two waves, when they meet under certain specific conditions. When the effect of one wave is constantly neutralised by the other, the two waves are said to interfere destructively (destructive interference) and when their effects are reinforced they are said to interfere constructively (constructive interference). As usual Interference is a basic characteristic of the wave.

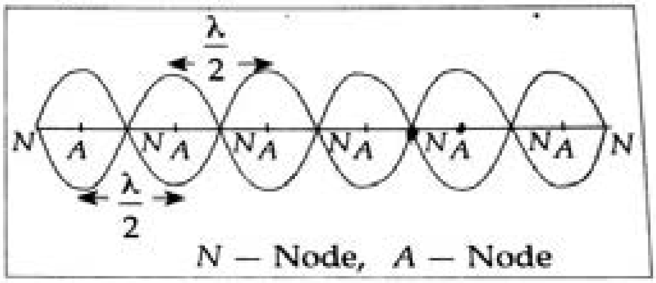
In sound when two sound waves trains meet at a point of a medium under certain suitable conditions stated below, then these two either interfere destructively producing a permanent *silence* or interfere constructively producing a permanent *anti-silence.*

Although total energy is conserved in the interference, here sound energy is transferred from the regions of *silence* to the regions of *anti-silence.*

(b) Beats : When two sound waves of the same amplitude but slightly different frequencies (not more than 16 Hz) travel along the same line, the loudness of the resultant sound wave formed by their superposition, fluctuates (varies) periodically and alternately which gives rise to a peak value with a waxing noise and then fading out with a waning noise. This phenomenon of waxing and waning in the loudness of the resultant wave is known as *beats*. Thus, the beats are formed due to the superposition of waves. Interferences and beats both occur due to the superposition of waves and these are concerned with the variation of the intensity of the wave. Interference is the phenomenon of sustained destruction or reinforcement of two identical waves and there is a spatial distribution of silence (destructive interference) and *anti-silence* (constructive interference) but in beats *silence* and anti-silence occur periodically at the same place, so it is also called *interference in time*. In producing interference the two interfering waves must be essentially coherent (having constant phase) but in producing beats any two sources can be taken.

(c) Stationary waves (standing waves)

When two identical progressive waves (waves having the same amplitude and frequency) travelling in the opposite directions meet along the same line with the same velocity, then the result of the superposition of such waves in the formation of a system of waves which alternately appear and disappear in the region where the two waves meet without advancing in either direction is called stationary (standing) waves.



In the formation of a stationary wave, the space confined has two types of points. The first is Node where no displacement takes place and another is Anti-node where maximum displacement occurs. The distance between two consecutive Nodes or Anti-nodes is $\frac{\lambda}{2}$; where λ is the wavelength of the waves undergoing for superposition.

(vi) Diffraction of sound : When sound waves originate by a vibrating source they spread in the medium and if the medium is homogeneous and isotropic (have uniform density), then these waves have spherical wave-fronts from the point source. Far from the source the wavefronts are nearly planes and the shape of the wavefront is changed when the wave meets an obstacle or an opening in its path. This leads to bending of the wave around the edges. Such bending of waves from an obstacle or an opening is called diffraction.

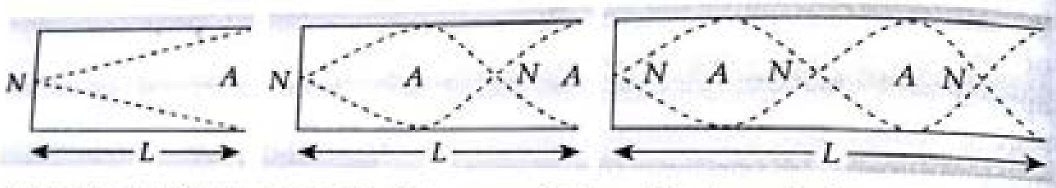
Diffraction is a characteristic property of the wave and all kinds of waves undergo diffraction. The effect of diffraction is appreciable when the dimensions of the obstacles are comparable or smaller than the wavelength of the wave. If the obstacle is large compared to the wavelength, the diffraction effect is almost negligible.

Example : The wavelength of the sound wave is approx. 1 meter and of the same order as the doors and windows of our houses. That's why sound wave is diffracted broadly and one person easily hears the voice of the another.

(vii) Vibration of air columns and organ pipes : Just as a string is used as a source of sound in various musical instruments, the vibration of air is used as source of sound in so many musical instruments like in chlorinet, sahnai, bansuri, organ pipe etc. A tuning fork is used as an exciter of vibrations in air and simultaneously performs two works— firstly it throws the air particles inside the pipe (open or closed) due to which forced vibrations are produced in the form disturbances which appear as a progressive wave and then a produced reflected wave is produced which interferes and forms a stationary wave.

It is observed that when a pulse of compressions through the tuning fork is incident on the closed end of a closed pipe, then the reflected wave appears as a pulse of compressions and similarly a pulse of rarefactions appears as a pulse of rarefactions. But in the open pipe a pulse of compressions is reflected as a pulse of rarefactions and vice-versa. Thus, in an open pipe compressions and rarefactions change into each other. Thus incident wave and reflected wave change their phase by π.

Closed organ pipe



In an organ pipe the closed end is essentially a *Node* and the open end is *Anti node*. The fundamental mode of vibration occurs when there is a Node at the closed end and an Anti node at the open end. As in the formation of a stationary wave, the distance between two adjacent Nodes or Anti nodes is $\frac{\lambda}{2}$. Thus, the distance between a Node and an Anti node = $\frac{\lambda}{4}$. $\Rightarrow L = \frac{\lambda}{4}$

The frequency of the fundamental mode is also called *first harmonic*.

$$\because \quad n_1 = \frac{v}{\lambda} = \frac{v}{4L} = \text{fundamental frequency.} \qquad \left(\because L = \frac{\lambda}{4} \Rightarrow \lambda = 4L\right)$$

But $v = \sqrt{\frac{E}{d}}$ where; E = Bulk modulus

d = density of the air.

$\Rightarrow n_1 = \frac{1}{4L}\sqrt{\frac{E}{d}}$ where; L = length of the pipe

Similarly, for the second mode of vibration, the frequency is called second harmonic or third overtone.

Here, $v = n_2\lambda$ i.e. $n_2 = \frac{v}{\lambda}$ $\left(\because L = \frac{\lambda}{2} + \frac{\lambda}{4} = \frac{3\lambda}{4}\right)$

$$\Rightarrow \quad n_2 = \frac{3}{4L}\sqrt{\frac{E}{d}} = 3n_1$$

Similarly, for the third mode of vibration; $v = n_3\lambda$ ie., $n_3 = \frac{v}{\lambda}$

$$\Rightarrow \quad n_3 = \frac{1}{\lambda}\sqrt{\frac{E}{d}} = \frac{5}{4L}\sqrt{\frac{E}{d}} \qquad \left(\because L = \frac{\lambda}{2} + \frac{\lambda}{2} + \frac{\lambda}{4} = \frac{5\lambda}{4}\right)$$

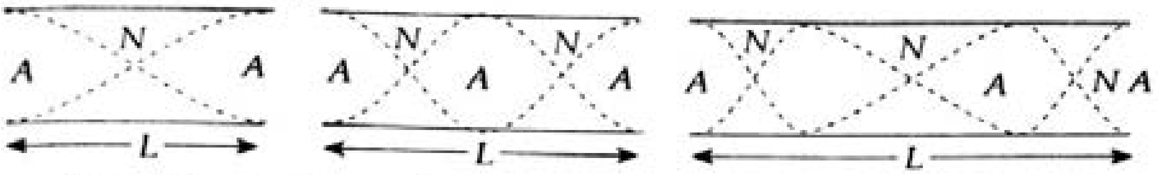
$$\Rightarrow \quad n_3 = \frac{5}{4L}\sqrt{\frac{E}{d}} = 5n_1.$$

Here, frequency is called third harmonic or fifth overtones.

Thus, $n_1 : n_2 : n_3 : \ldots\ldots\ldots$

$= 1 : 3 : 5 : \ldots\ldots\ldots$ Thus, possible tones of a closed pipe have frequencies in the ratio of odd integers. Notes emitted by the air column in a closed pipe have only alternate overtones and hence poor harmonics.

Open organ pipe



When the air column is contained in an open pipe, the two ends are essentially Anti nodes and then it is said to be in the fundamental mode of vibration of the air column.

Obviously, $L = \frac{\lambda}{2}$, and $v = n_1\lambda$

$$\Rightarrow \quad n_1 = \frac{v}{2L} = \frac{1}{2}\sqrt{\frac{E}{d}} \qquad \left(\because v = \sqrt{\frac{E}{d}}\right)$$

This is the fundamental frequency or first harmonic. Similarly frequency of second mode or second harmonic or first overtone

$$= n_2 = 2\frac{v}{2L} = 2\frac{1}{2L}\sqrt{\frac{E}{d}} = 2n_1.$$

and frequency of third mode or third harmonic or second overtone

$$= n_3 = 3\frac{v}{2L} = 3\frac{1}{2L}\sqrt{\frac{E}{d}} = 3n_1.$$

Thus, $n_1 : n_2 : n_3 : \ldots\ldots\ldots = 1 : 2 : 3 : \ldots\ldots\ldots$

Thereby it can be concluded that the possible tones of an open pipe have frequencies in the ratio of natural numbers. The note emitted by the air column in an open pipe will have the full series of overtones and hence it is very rich in harmonics. That's why the quality of a note emitted by an open pipe is always better and sweeter than that of a closed pipe.

6. Doppler's effect in sound

When there is a relative motion between an observer and a source, then the pitch of the note emitted by the source appears to be changed to the observer. This apparent change in pitch due to a relative motion between the observer and the source and also sometimes due to motion of the medium is called Doppler's effect in sound (acoustical Doppler's effect).

Actually Doppler firstly observed this effect in light waves. Thus, the optical Doppler's effect in fact firstly propounded the spectral lines of certain stars which were found to be shifted towards the red or violet end of the spectrum from their normal position by a very small distance. For the red and violet end stars recede from the earth and approach to the earth respectively. Doppler's effect is also a basic characteristic of the wave and it is to be found in all types of wave.

The acoustical (sound) Doppler's effect can be observed from a railway platform when a whistling locomotive engine passes the platform at a very high speed. Before passing the platform the pitch of the whistling appears higher and after passing the platform, its pitch appears lower

The formula derived for Doppler's effect in sound is—

Apparent pitch or frequency (n')

$$= \frac{\text{relative velocity of the observer with respect to velocity of sound}}{\text{relative velocity of the source with respect to velocity of sound}} \times \text{Actual pitch or frequency}$$

Thus, $n' = \dfrac{v \pm v_o}{v \pm v_s} \times n$

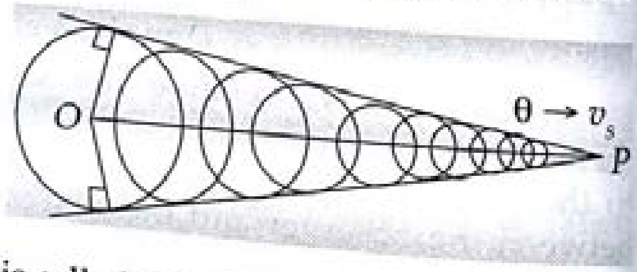
where, n' = apparent pitch or frequency.
n = actual pitch or frequency.
v = velocity of sound.
v_o = velocity of the observer.
v_s = velocity of the source.

Sonic booms, Shock waves and Mach-number :

When the velocity of a source exceeds the phase velocity of a sound wave, then Doppler's effect fails and it has no meaning. There are many instances in which, source moves through a medium at a velocity greater than the velocity of sound. A jet plane, a ballistic missile moves through the air at a velocity greater than the velocity of sound. In such cases the wavefront takes the shape of a cone with moving object at its apex. The Jet plane or the supersonic plane sends a cracking sound called *sonic boom* which can crack glass dishes, window panes and even damage buildings. The wave originated due to sonic boom is called *shock wave*. The spherical wavefront intersect over the surface of the cone with the apex at the source. Because of constructive interference of a large number of waves arriving at the same instant on the surface of the cone, pressure waves of very large amplitude are sent with a conical wave front. Such waves are shock waves.

Here, we can write $\sin\theta = \dfrac{v}{v_s}$

where, v = velocity of sound
v_s = velocity of source.



In aerodynamics, this ratio $\left(\dfrac{v}{v_s}\right)$ is called *Mach-Number.*

If Mach-Number $\left(\dfrac{v}{v_s}\right) > 1$, the velocity of the source like jet plane (supersonic plane) is called *Supersonic.*

If Mach-Number $\left(\dfrac{v}{v_s}\right) > 5$, then the velocity of the source is called *Hypersonic.*

III. Thermal Physics (Heat & Thermodynamics)

1. Heat & Temperature

The degree of hotness or coldness of a body is called its **temperature** and thus temperature is an indicator of the thermal stage of the body. Due to different temperatures of two bodies thermal energy transfers from the body having higher temperature to the body of lower temperature and at a particular temperature the process of energy transfer stops and now both bodies are said to be in *thermal equilibrium*. This thermal energy due to which the existence of the temperature in the body appears is called *heat*. In other words, heat is a type of energy by which mechanical work can be done. This was firstly detected by Rumford. Later, Davy confirmed this fact after rubbing two pieces of ice on melting. As no source of heat is available in the melting of the two pieces thus frictional forces came into existence due to the rubbing, which produce heat energy and consequently the two ice pieces melt. Later by Joule's experiment it was observed that heat is a form of energy by which various works can be performed. Joule also asserted that heat and mechanical work are inter-transferable to each other and the ratio of mechanical work and heat energy by which work is done is a fixed ratio called mechanical equivalent of heat and basically it is a conversion unit. If a mechanical work W is produced by an amount of heat H then

$J = W/H$ or $W = JH$, where; J = mechanical equivalent of heat.

$= 4186$ Joule/kilo cal.

$= 4.186$ Joule/cal.

$= 4.186 \times 10^7$ erg/cal.

This implies that if work of 4.186 Joule is done then 1 kilo cal. heat would be produced.

Effect of heat :

(a) Physical changes : By the application of heat or thermal energy the physical structure of a body like its shape-size, volume, temperature and its state changes.

(i) Change in Temperature : Ordinarily temperature of a body increases with increase in heat or on supplying thermal energy to it.

(ii) Change in Volume : Ordinarily with increase in heat or thermal energy the volume of the body increases.

(iii) Change of state : Usually there are three states of matter— solid, liquid and gas and these states exist due to the difference of temperature thereby due to heat. Thus, change of state takes place due to heat.

(iv) Others changes: On heating a body its shape, size, electrical resistance, the ability to dissolve solute in the solvent etc. change drastically.

(b) Chemical changes : On heating a substance some changes occur permanently. One can observe free oxygen released on heating potassium chlorate with mangnese dioxide.

Units of Heat : The SI unit of heat is Joule and in C.G.S. its unit is calorie.

Calorie : The amount of heat required to raise the temperature of 1 g water by 1°C is called calorie.

International calorie : The amount of heat required to raise the temperature of 1 g water by 1°C (from 14.5°C to 15.5°C) is called International calorie.

British Thermal Unit (B.Th. U.) : The amount of heat required to raise the temperature of 1 pound water by 1°F is called 1 B.Th.U.

Relation among different units :

1 B.Th.U. = 252 cal.
1 cal. = 4.186 Joule
1 Joule = 0.24 cal.
1 kilo cal. = 4.186×10^3 Joule = 1000 cal.

Thermometry : The branch of thermal physics in which temperature is measured by various devices like thermometers, thermocouple, total radiation pyrometer etc is called thermometry.

All thermometers operate on the single principle by use of the substance whose volume expansion is directly dependent on the temperature. The thermometers are of various types which are fabricated and designed for the different means and purposes.

Thermometers are of many types—Liquid thermometer (based on the expansion of volume of the liquid by increase in temperature.), Gas thermometer (expansion in volume of the gas with increase in temperature), platinum resistance thermometer etc.

Liquid thermometer : In liquid thermometers mercury or alcohol is mainly used. Alcohol is used in those liquid thermometers which measure the temperature of below – 40°C. The freezing point of alcohol is – 115°C so alcohol thermometer doesn't work below-115°C. The freezing and boiling points of the mercury are – 39°C and 357°C respectively. Thus, mercury thermometer is fabricated and designed to remain operational from 30°C to 350°C.

Clinical thermometer : To measure the temperature of the human body a suitable thermometer has been fabricated and designed on Fahrenheit scale and it is called clinical thermometer. Since the temperature of the human body varies in very short span, thus in clinical thermometers lower fixed point is kept at 95°F (35°C) and upper fixed point at 110°F (43°C).

Gas thermometer : Constant volume hydrogen gas thermometer is a standard gas thermometer from which every other gaseous thermometers are fabricated. The temperature upto 500°C can be measured through it and if hydrogen is replaced by nitrogen then temperature up to 1500°C can be measured.

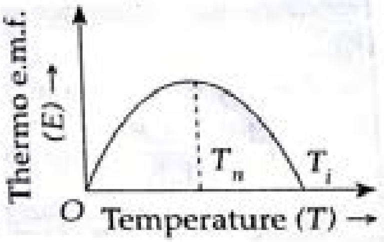
Platinum resistance thermometer : This thermometer is constructed on the basis that the resistance of a metal increases quite uniformly with the rise of temperature. The great advantage of this thermometer is that it measures very wide temperature ranges from – 200°C to 1200°C. The value of the temperature measured by platinum thermometer is so consistent, precise and accurate that this thermometer can be used to standardise the other thermometers.

The platinum resistance thermometer has a large thermal capacity and the protecting tube has low thermal conductivity so this thermometer doesn't attain the temperature of the bath quickly in which it is immersed.

Thus, this thermometer has an excessive time lag. Further, some time is also lost in balancing the bridge. That's why this thermometer is not suitable for measuring rapidly varying temperatures.

Thermo-couple : This is a special type of temperature measuring device in which two junctions are constructed by different metals— one junction is hot and another is cold and due to thermoelectric effect temperature is measured and this effect is called Seebek's effect.

In 1923 Seebek discovered that when two dissimilar metals are joined to form a closed circuit and a difference of temperature is established between their junctions, an e.m.f. is developed and hence an electric current flows through the circuit. The e.m.f. so produced is called thermoelectric e.m.f. and the phenomenon is called Seebek effect. Such an arrangement of connecting two dissimilar metals together is called a thermo-couple. The magnitude of thermo-electric e.m.f. depends upon the nature of two metals and on the temperature difference of their junctions.



At a particular temperature of hot junction thermo-e.m.f. becomes maximum. This temperature of the junction (at which e.m.f. in thermo-couple is maximum) is called *neutral temperature* T_n for the thermo-couple.

Neutral temperature is constant for a given pair of metals forming the thermo-couple. If the temperature of hot junction is raised further, the thermo e.m.f. decreases and becomes zero at a particular temperature which is called *temperature of inversion* T_i. Beyond inversion temperature T_i, thermo e.m.f. again increases but in reverse direction. Temperature of inversion is too much above than neutral temperature as the temperature of cold junction is below to it. Thus, inversion temperature is not constant for a given thermo-couple, but depends on the temperature of cold junction. Here, a relation between neutral temperature and inversion temperature is given by,

$$T_i - T_n = T_n - T_c \Rightarrow T_n = \frac{T_i + T_c}{2}$$

where, T_i = temperature of inversion.

T_n = neutral temperature.

T_c = temperature of cold junction.

Thermo e.m.f. in the circuit varies with temperature of hot junction is graphically obtained which is a parabolic curve given by a relation $E = AT + BT^2$ (a parabola). Here, cold junction is kept at 0°C, while A, B are constant and t is the temperature of hot junction.

Total radiation pyrometer : This is also a temperature measuring device through which the temperature of bodies like stars, sun etc. (which have very high order temperatures) are measured which are far away from us. Thus, radiation pyrometer is a device through which by the estimation of radiation without touching the bodies, temperatures are measured. Total radiation pyrometer operates on the principle of Stefan's law and according to which heat radiation emitted per second per unit area is proportional to the fourth power of the absolute temperature. The body having temperature less than 800°C doesn't emit a suitable (detective) radiation and that's why through the total radiation pyrometer the temperature of only those bodies are measured which have a temperature of more than 800°C.

Various scales of temperature measurement : In the construction of thermometers two fixed points are selected on various scales in which there is a maximum point called Upper Fixed Point (U.F.P.) and there is a minimum point called Lower Fixed Point (L.F.P.). There are various scales like Celsius (or centrigrade), Fahreneit, Reaumur, Kelvin and Rankin.

Generally; the freezing point of ice is taken as L.F.P. and the boiling point of pure water at 76 cm of Hg is taken as U.F.P. The difference between the U.F.P and L.F.P. is called Fundamental difference or Interval (F.I.)

Scale	L.F.P.	U.F.P.	F.I.
Celcius	0° C	100° C	100
Fahrenheit	32° F	212° F	180
Reaumur	0° R	80° R	80
Kelvin	273 K	373 K	100
Rankin	492 R_n	972 R_n	180

For any thermometer;

$$\frac{\text{Reading} - \text{L.F.P.}}{\text{U.F.P.} - \text{L.F.P.}} = \text{a constant}$$

Thus, $$\frac{C-0}{100-0} = \frac{F-32}{212-32} = \frac{R-0}{80-0} = \frac{K-273}{373-273} = \frac{R_n-492}{672-492}$$

or, $$\boxed{\frac{C}{100} = \frac{F-32}{180} = \frac{R}{80} = \frac{K-273}{100} = \frac{R_n-492}{180}}$$

Absolute zero : Theoretically there is no limit of maximum temperature but there is a limit or restriction on the minimum temperature. The lowermost temperature is – 273.15°C and it is called *absolute temperature.*

On Kelvin scale absolute temperature is expressed as 0 K and it is the required temperature on which molecular motion of the body is ceased.

Thus, $0\text{ K} = -273.15°\text{C} \Rightarrow 273.15\text{ K} = 0°\text{C}$

$\Rightarrow \quad 0°\text{C} = 273.15\text{K}.$

$$\boxed{K = (273.15 + °C)}$$

It is a convention in Physics (which is strictly followed) that the temperature of the kelvin scale is never represented in degree.

Some temperature on various scales :

Temperature	**Celsius (°C)**	**Fahrenheit (°F)**	**Kelvin (K)**
Freezing of water	0°C	32°F	273 K
Normal temperature of the room	27°C	80.6°F	300 K
Normal temperature of the human body	37°C	98.6°F	310 K
Boiling point of water	100°C	212°F	373 K

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2. Thermal expansion of solids, liquids and gases

Ordinarily the volume of a substance increases with the supply of heat (thermal energy) resulting from the increase of intermolecular distances in the substance. But there are some exceptions also for instance, in water volume contracts on increasing its temperature from 0°C to 4°C. Similarly in Silver Iodide (AgI) volume contracts on increasing the temperature if it has temperature between 80°C to 140°C. On supplying heat expansion occurs in all solids, liquids and gases, but gases expand more than liquids and liquids expand more than solids.

Expansion of solids : Usually if any solid body is heated, it expands in length, breadth and thickness and if the expansion, in length is only substantial then it is called linear expansion but if both length and breadth expand substantially it is called superficial expansion and ultimately if the length, breadth and thickness all expand, then it is called volume expansion (cubical expansion).

Coefficient of linear expansion—It is defined as increase in per degree celsius temperature with unit length of the body and it is represented by α.

Thus, coefficient of linear expansion

$$= \frac{\text{increase in length}}{\text{original length} \times \text{increase in temp.}} \quad \Rightarrow \alpha = \frac{\Delta L}{L \times \Delta\theta}$$

Coefficient of linear expansion is represented by α and its unit is per degree celsius.

Coefficient of superficial expansion : It is defined as increase in per degree celsius temperature with increase in unit area of the body and it is represented by β.

Thus, coefficient of superficial expansion

$$= \frac{\text{increase in area}}{\text{original area} \times \text{increase in temp.}} \quad \Rightarrow \beta = \frac{\Delta s}{s \times \Delta\theta}$$

Coefficient of cubical expansion—It is defined as increase in per degree celsius temperature with increase in unit volume of the body and it is represented by γ.

Thus, coefficient of cubical expansion

$$= \frac{\text{increase in volume}}{\text{original volume} \times \text{increase in temp.}} \quad \Rightarrow \gamma = \frac{\Delta V}{V \times \Delta\theta}$$

Here, it is observed that $\beta = 2\alpha$ and $\gamma = 3\alpha$

Thus, $\alpha : \beta : \gamma = 1 : 2 : 3$

Application related to expansion of solids :

(i) Railway tracks are constructed from iron and steel and these are made adjustable to sustain tremendeous load and the thermal expansion. That's why some free space is left at the joints of two such tracks.

(ii) If we pour or keep hot water inside a thick glass (jar) then the inside surface of the jar suffers thermal expansion while outer surface of the jar remains unaffected due to its thickness that's why glass jars crack.

Today good quality glass jars are constructed through pyrex glass whose thermal expansion is negligible and jars can be protected from cracking.

(iii) As time period of a pendulum clock is given by $T = 2\pi\sqrt{\frac{l}{g}}$, from its time period obvjously depends on the length of the pendulum. In summer the length of a pendulum increases, so its time period increases and consequently the pendulum clock slows down. But in winter the length of the pendulum contracts so the time period decreases and pendulum clock oscillates fast. Today pendulum clocks are constructed through those metallic bodies which have negligible thermal expansion and contraction.

Expansion of liquids : As there is no shape of liquids like solids, liquids are always kept in a container (vessel). So linear expansion and superficial expansions in liquids have no relevancy and significance. So cubical expansion (volume expansion) in the liquids has only the appropriate meaning. As soon as heat (thermal energy) is supplied the liquid starts to expand but along with it, its container (vessel) also starts to expand. Actually up to what extent liquid originally expands it doesn't perceive and its expansion is slightly less than the original because some thermal energy is used up in expanding the container.

This shows that there are two types of thermal expansions one is apparent and the other is real. Thereby coefficient of apparent volume expansion (γ_a)

$$= \frac{\text{apparent increase in volume}}{\text{original volume} \times \text{change in temp.}}$$

and coeff. of real volume expansion (γ_r)

$$= \frac{\text{real increase in volume}}{\text{original volume} \times \text{change in temp.}}$$

Thus, if γ_g be the coeff. of volume expansion of the glass the vessel (container) then, γ_r (coeff. of real volume exp.)

$= \gamma_a$ (coeff. of apparent volume exp.)

$+ \gamma_g$ (coeff. of volume expansion of glass)

The density of substance is defined as the ratio of the mass of the substance and its volume. As the volume of a substance increases on heating, its density would correspondingly decrease, its mass being constant. But this effect is negligible for solids and prevailents in liquids because change in volume in solids are very small.

Anomalous expansion in water : Ordinarily the volume of most liquids increases with supply of heat (thermal energy) while its density decreases. But the behaviour of water is just opposite. If water at 0°C is to be heated up to 4°C, its volume decreases and density increases. At 4°C the volume of water is minimum and its density is maximum but with increase in temperature water behaves like an ordinary liquid. Thus if water of 4°C is to be heated further then its volume increases and density decreases. This is called *anomalous expansion of water.* There are so many incidents of anomalous expansion of water in our aquatic life. In the winter season specially in cold regions when atmospheric temperature falls, the upper layer of the water of the lakes and ponds are frozen and consequently density increases while the lower layer of the water is comparatively warmer and this process continues until the total volume of water attains the temperature of 4°C. If the atmospheric temperature falls more sharply, the density of the outer layer of water starts to diminish due to the anomalous expansion of water. Consequently the outer layer is remained frozen at 0°C and the lower layer of the water is in liquid state of 4°C. That's why in the lower layer of the water of the lakes and ponds the fishes and others aquatic organisms live. Due to the anomalous expansion of water the water pipes in the cold regions burst (crack). Since at 0°C water freezes and on transforming it into the ice its volume increases which brusts the tanks (pipes).

Expansion of gases : Gases are the most active substances which take part in thermal expansion. On supplying heat to the gases not only their temperature increase but the pressure and volume also change under the suitable condition. Boyle's law, Charle's law etc. were derived from these conditions.

Boyle's law - pV = a constant (at constant temperature).

Charle's law - $\frac{V}{T}$ = a constant (at constant pressure).

Boyle's and Charle's law together give gas equation.

$$\frac{pV}{T} = \text{a constant, called gas constant } (R)$$
$$= 8.31 \text{ joule/mole-kelvin.}$$

Calorimetry : The branch of thermal physics in which heat is measured by the principle of heat lost and heat gained is called calorimetry and the apparatus used for the purpose is called calorimeter. The calorimeter is made of copper. The principle of calorimetry states that the total heat lost is equal to the total heat gained and this is based upon energy conservation principle.

The heat lost or gained by a body depends on the mass of the body and on the rise or fall in its temperature.

Thus; $\Delta Q = ms\Delta\theta$.

where; s is a constant called specific heat capacity of the body

m = mass, $\Delta\theta$ = rise or fall in temperature.

Specific heat capacity : This is defined as the amount of heat required to raise the temperature of 1 kg of a substance through 1 K thus

$$\Delta Q = ms\Delta\theta \qquad \Rightarrow s = \frac{\Delta Q}{m\Delta\theta}$$

If $m = 1$ kg and $\Delta\theta = 1$ kelvin then $s = \Delta Q$

S.I. unit of specific heat capacity is J kg^{-1} K^{-1} and in CGS it is cal. gm^{-1} °C^{-1}.

Thermal capacity : It is defined as the amount of heat required to raise the temperature of a given amount of a substance through 1 kelvin, thus thermal capacity = ms Joule/kelvin or cal. °C^{-1}.

Specific heat capacity of some important substances

Substance	Sp. heat (cal./gm°C)	Substance	Sp. heat (cal./gm°C)
Lead	0.03	Water	1
Brass	0.09	Ice	0.50
Iron	0.11	Alcohol	0.60
Carbon	0.17	Tarpin	0.42
Silica (sand)	0.20	Magnesium	0.25
Aluminium	0.21	Zinc	0.092

Specific heat capacities and Molar heat capacities of the gases

On supplying a substantial amount of thermal energy to gases the temperature of the gases increase and both volume and pressure change along with it. Thus, it can also be interpreted as the temperature variation with pressure at constant volume and the temperature variation with volume at constant pressure. That's why gases have two specific heat capacities— one at constant pressure indicated by C_p and another at constant volume indicated by C_v. Here it is also observed that specific heat at constant pressure is greater than specific heat at constant volume.

Specific heat capacity at constant pressure (C_p) : The amount of heat required to raise the temperature of 1 kg mass of a gas through 1 K at constant pressure is called specific heat capacity of the gas at constant pressure (C_p)

Specific heat capacity at constant volume (C_v) : The amount of heat required to raise the temperature of 1 kg mass of a gas through 1 k at constant volume is called specific heat capacity of the gas at constant volume (C_v).

Molar heat capacity at constant pressure (C_p) : The amount of heat required to raise the temperature of 1 mole (gm-molecule) of a gas through 1K at constant pressure is called molar heat capacity at constant pressure (C_p).

Molar heat capacity at constant volume (C_v): The amount of heat required to raise the temperature of 1 mole (gm-molecule) of a gas through 1K at constant volume is called molar heat capacity at constant volume (C_v).

Relation between C_p and C_v :

(i) C_p is greater than C_v and Mayer established a relation; $C_p - C_v = R$, called Mayer's relation.

Here R is called gas constant and its value $= 1.99 \simeq 2$ cal/mole-K

$= 8.31$ Joule/mole-K

(ii) $\frac{C_p}{C_v} = \gamma =$ ratio of specific heat capacities.

Water equivalent : This is quantity of water in kg which will require the same amount of heat to raise its temperature through 1K as it is required by the body when heated through the same temperature. Thus, its unit is gm or kg.

If m be the mass of a body in kg and s be the specific heat in SI unit, then water equivalent of the body $= W = \frac{ms}{4200}$

Obviously; water equivalent (in gm) and thermal capacity (in cal./°C) are numerically equal.

Latent heat of fusion : The latent heat of fusion of a substance is defined as the quantity of heat required to convert 1 kg of the substance from solid to liquid state without change of temperature at its melting point. It is expressed in cal/gm in CGS unit and in Joule/kg in SI unit.

Thus, $Q = mL$
where, Q = heat required
m = mass of the substance (solid)
L = Latent heat of fusion.

Latent heat of ice (latent heat of fusion of ice) = 80 cal/gm

$$= \frac{80 \times 4.2}{10^{-3}} \text{ Joule/kg.}$$

$$= 336 \times 10^3 \text{ J/kg}$$

Latent heat of vaporisation : The latent heat of vaporisation of a substance is defined as the quantity of heat required to convert 1 kg of the substance from liquid to vapour state without change of temperature at its boiling point. It is also expressed in cal/gm in CGS unit and in Joule/kg in SI unit.

Thus, $Q = mL$,
where, Q = heat required
m = mass of the substance (liquid)
L = latent heat of vaporisation

Latent heat of water (latent heat of vaporisation of water)

$$= 536 \text{ cal/gm} = \frac{536 \times 4.2}{10^{-3}} \text{ J/kg} = 2250 \times 10^3 \text{ J/kg}$$

Change of state of matter : A substance can be found only in three states of matter– solid, liquid and gas. If a certain amount of thermal energy be supplied to the solid state then at a particular temperature (melting point of the solid) it is converted into liquid and this thermal energy is latent heat of fusion and conversely if such energy be withdrawn from the liquid it would be transformed back into the solid state. Similarly the liquid is converted into the gas (vapour) at a particular temperature (boiling point of the liquid) and the thermal energy supplied is latent heat of vapourisation. Conversely by withdrawing required thermal energy, the gas could be again transformed back into the liquid state.

✓ Steam at 100°C is hotter than water at 100°C though water is boiling. This is strange but true because boiling water has only thermal energy whereas steam has thermal energy plus latent heat of vaporisation. Because of this steam is more painful than boiling water.

Most metals are found to be in solid state but mercury (Hg) exceptionally is the only metal found in liquid state.

Melting point of a solid : A constant temperature at which a solid is transformed into liquid by the supplied heat energy of latent heat of fusion is called its melting point (m.p).

Effect of pressure : When a solid melts, there may be an increase or decrease in volume with the application of pressure. The melting point of certain solids like wax and sulphur increases with increase in pressure, while the melting point of certain solids like ice, gallium and bismuth decreases with increase in pressure. Thus, ice will melt at a temperature lower than 0°C when the pressure is higher than that of the normal pressure.

Effect of Impurity : Normally the m.p. of solid decreases more sharply on mixing impurity. Example- If some salts or perfumes are added to ice of 0°C then its melting point decreases upto - 22°C.

Freezing point : At a fixed temperature the transformation of a liquid into the solid by lowering the temperature or withdrawing the thermal energy (latent heat of fusion) is called freezing point. The freezing point coincides with the melting point of the solid.

Boiling point of a liquid : A constant temperature at which a liquid is transformed into gas (vapour) by the supplied heat energy of latent heat of vaporisation is called boiling point (b.p).

Effect of pressure : When a liquid boils i.e. changes from liquid to gas there is an increase in its volume. Thus the boiling point of a liquid rises with increase in pressure and vice-versa. Thus a liquid will boil at lower temperature under reduced pressure. Hence; water will boil at a temperature lower than 100°C when the pressure applied is less than normal pressure.

Effect of Impurity : On mixing the impurity boiling point of the liquid increases.

Condensation point : At a constant temperature the transformation of vapour into the liquid is called condensation point and usually the condensation point and boiling point of the liquid coincides.

Difference between vapour and gas : If the liquid boils at a particular temperature (b.p) then after a few seconds latter latent heat of vaporisation generates the vapour. But a few seconds latter vapour increases its temperature which is called critical temperature (T_c) above which vapour is called gas.

3. Transmission of heat

Due to substantial temperature difference the heat is transferred from one place to another in a substance then it is called transmission of heat. There are three processes (modes) of the transmission of heat—

(i) Conduction (ii) Convection and (iii) Radiation.

(i) Conduction : By the process of conduction heat is transferred from one place to another by the particles vibrations of the substance but these particles do not leave their occupied position. In fact when a substance is being heated then the molecules (particles) start to vibrate rapidly (vigorously) and this kinetic energy of vibration of the particles is transferred which appears as heat energy and it is called the phenomena of thermal conduction. In solid, heat is transmitted by the process of thermal conduction only but this process is not relevant and significant in liquid and gas. The process of transmission of heat in the substance is called thermal conductivity. The rate of thermal (heat) energy transmitted through the substance (conductor) depends on various parameters like area of cross section, temperature difference between the faces of the substance and the thickness of the substance and it is given as— the rate of thermal energy transmitted $= \left(\frac{Q}{t}\right) = \frac{k A \Delta\theta}{\Delta t}$

where k is a proportionality constant called coefficient of thermal conductivity whose value is different for different substance (conductor) and depends on its material.

A = area of cross-section
$\Delta\theta$ = difference in temperature
Δt = thickness
Δt = change in time

Also here, $\frac{\Delta\theta}{\Delta t}$ is called temperature gradient

On the basis of thermal conductivity the substances are classified in the following types—

(a) Good conductor : The substances through which heat is transmitted very easily and conveniently are called good conductors or conductors. Most of the metallic solids are good conductors.

Examples : Metals, acidic water, human body etc. are good conductors.

(b) Bad Conductor : The substances through which heat is not transmitted easily and conveniently and a little amount of heat transfers are called bad conductors. Examples– Wood, fiber, glass, rubber, air etc. are bad conductors.

(c) Thermal Insulator : The substances through which heat is not transmitted by any means (methods) are called thermal insulators. In fact bad conductors are sometimes synonymously used as thermal insulators. Thus, we can say bad conductors are good insulators. In garments and cloths air is trapped which provides a good insulating characteristic.

Examples— Abonite, asbestos etc are insulators.

(ii) Convection : In the process of convection heat is transmitted in the substance by transfer of molecules (particles) of the substance and thus a current due to the molecules transfer is generated which is called convectional current.

In liquid and gas heat is transmitted by the process of convection and as molecules of solid are not free to move, so heat cannot be transmitted in solid by the process of convection. Whenever a liquid or a gas is heated, the molecules (particles) of these substances become lightened and move upwards and then cooler molecules settle downwards and heated. Now a convectional current is formed and heat is transmitted throughout in the liquid or gas. The atmosphere of our earth is heated by the process of convection.

(iii) Radiation: In the process of radiation there is no need of any medium for the transmission of heat, while in conduction and convection a medium is necessarily needed. In fact thermal radiation is an electromagnetic wave which can transmit even in vacuum. Thus we can say that in the process of radiation thermal energy transmits anywhere without interfering with and heating the medium through which it passes. We obtain heat (thermal energy) from the sun by the process of radiation on the earth's surface. Thus, thermal radiations (simply radiation) are the electromagnetic waves which on being absorbed by the certain bodies manifest themselves as heated. But there are also other electromagnetic waves that stimulate the sensation of vision and these are called luminous radiations, while those producing chemical changes are called actinic radiations.

Difference between thermal radiation and light radiation : Thermal radiation (heat radiation) and light radiation (optical radiation) both have the same form of radiant energy and the difference between them is a difference of frequency or wavelength, but not of kind.

Sources of thermal radiations : Any hot body maintained at a constant temperature may serve as a source of thermal radiations. The earliest source of thermal radiations suitable for simple experiments on radiation is a leslie cube which is simply a hollow cube of metal blackened on one side with lamp-soot. When the boiling water is poured into it, radiations are emitted from blackened surface. But now at present two special devices have been designed by Fery and Wien's black bodies which are usually used as the source of thermal radiations. The ideas of these radiations came from the concept of black body and the theoretical fact is that the quality of radiations inside a uniformly heated enclosure is exactly the same as that of black body radiations (radiations from a hot black body).

Black body : A perfectly black body is one which absorbs completely all the radiations of whatever wavelength incident upon it. Since it neither reflects nor transmits any radiation, it appears black whatever the colour of the incident radiation may be. If a black body is placed inside a uniform temperature enclosure, it will absorb the full radiation of the enclosure. The quantity and quality of the radiation inside a uniform temperature enclosure is not affected by the presence of any body inside it, the black body will emit the full radiation of the enclosure on attaining equilibrium temperature with it. Thus, the radiation emitted by a black body is also the full radiation consisting of all possible wavelength.

But there is no surface available in practice which will absorb all the radiation falling upon it. Even the lamp-blacked surface which is assumed to be a perfectly black body and which absorbs practically all the visible and infra-red radiations, reflect the far infra-red radiation.

Emissive power and Absorptive power : The emissive power of a body at a given temperature and for a given wavelength is defined as the radiant energy emitted per second per unit surface area of the body per unit wavelength range. It is symbolically represented by e_{λ}.

The absorptive power of a body at a given temperature and for a given wavelength is defined as the ratio of the radiant energy absorbed per second by the surface of the body to the total energy falling per second on the same area. It is symbolically represented by a_λ.

Kirchhoff's law : It states that the ratio of emissive power to absorptive power for a radiation of a given wavelength is the same for all the bodies at the same temperature and it is equal to the emissive power of a perfectly black body at that temperature.

$$\text{Thus} \quad \frac{\text{emissive power of any body } (e_\lambda)}{\text{absorptive power of that body } (a_\lambda)}$$

$$= \text{emissive power of black body at the same temperature } (E_\lambda).$$

This law also concludes that if a body absorbs radiation of a particular wavelength strongly, it also emits the same radiations strongly. Thus, the alternate statement of Kirchhoff's law is *good absorbers are good emitters.*

Red glass appears red because from the thermal radiation incidents upon it red colour is totally reflected and other colours are absorbed. If the red colour from the white light is withdrawn, then this would seem to appear green. That's why when a red glass is heated for a long time, it appears green and conversely on heating a green glass it appears red.

Stefan's law : It states that the total radiant energy (E) emitted per second from unit surface area of a black body is proportional to the fourth power of its absolute temperature (T)

Thus, $\boxed{E \propto T^4} \Rightarrow E = \sigma T^4$, Here, σ is called Stefan's constant.

Boltzmann established this law theoretically from a thermodynamical consideration and hence an extended form of Stefan's law is called Stefan Boltzmann's law which is stated as below—

If a black body at an absolute temperature T is surrounded by another black body at an absolute temperature T_o, then it will lose an amount of energy σT^4 per sec per unit area and will gain an amount of energy σT_o^4 per sec per unit area from the surroundings. Hence the net loss of energy per sec per unit area of the body will be $E = \sigma(T^4 - T_o^4)$ which is called Stefan–Boltzmann's law.

Newton's law of cooling : It states that the rate of loss of heat energy of any hot body by the process of thermal radiation is proportional to the difference between the mean temperature and the surroundings.

$$\text{Thus the rate of heat energy lost } \left(\frac{Q}{t}\right) = k\left(\frac{\theta_1 + \theta_2}{2} - \theta_0\right)$$

where, k = a proportionality constant

θ_1, θ_2 = two temperatures of small time interval.

θ_0 = temperature of the surrounding.

t = time

It is observed that if a hot body loses its heat energy in such a way that its temperature falls from 70°C to 60°C in particular time t min, then it will take more than t min. in the temperature falling from 60°C to 50°C. By the process of radiation the heat energy lost not only depends upon the temperature difference of the body and the surroundings, but also on the nature of the surface of the body and its surface area.

For a small temperature difference of the body and surroundings Newton's law of cooling becomes just an approximation of Stefan Boltzmann's law of radiation.

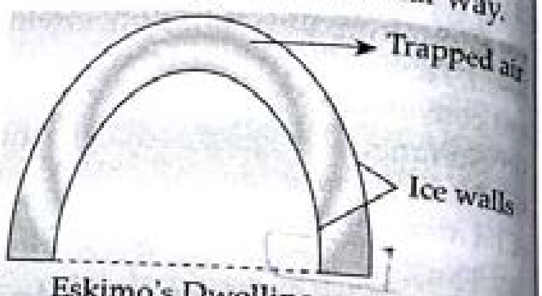
Utilities and Applications of transmission of heat in our daily life

(A) Utilities and Applications of conduction

(i) When we touch a piece of iron and wood placed in the same room, we feel iron to be colder than the wood. The reason behind it is good conduction of heat by the iron in comparison to the piece of the wood.

Our body temperature (normally 37°C) is generally greater than that of the room. When we touch an iron piece, heat is rapidly conducted from the hand (hotter body) to the iron but wood being a bad conductor conducts very little amount of heat. So we lose more heat by touching iron than wood. That's why an iron piece appears colder. But when both are kept in the open sky under the sun, then on touching the iron piece it appears hotter than the wooden piece. This can also be explained exactly in the similar way.

(ii) Eskimos live in the houses of double walls of ice as shown in the figure. Such houses keep people warmer and comfortable because air molecules are being trapped between the ice walls of the house which is bad conductor of heat.



Eskimo's Dwelling

(iii) To drink tea in a metallic cup is painful than to drink tea in a ceramic or fiber cup. The simple reason behind it is that heat from the tea goes into the metallic cup which becomes hot and ones lips have painful and bitter experience due to good conduction of heat. But due to bad conduction of heat, in ceramic or fiber cup heat doesn't travel from tea to the cups and does not warm.

(B) Utilities and Applications of convection

(i) Ventilation : The ventilation of a room is the process of expulsion of warm and impure air and induction of cold and fresh air into the room. For proper ventilation an outlet is necessary near the top of the room and an inlet near the bottom of the room. The hot and impure air being lighter escapes from the top outlet and fresh air enters into the room through the inlet at the bottom of the room.

(ii) Chimney : Smoke issuing from chimneys is a common phenomenon and in a chimney the process of convection occurs. Hot air and smoke being lighter move up through the chimney while the cold and heavier air is continuously drawn inside the bottom. Thus, a convectional current is set up. In the tall chimney the difference in the density of air between the top and the bottom is large. Narrow chimneys are being preferable to wide ones because they can prevent downward currents of air more effectively.

(iii) Winds and breezes : Trade winds, land breeze and sea breeze are natural consequences of convection. The equatorial belt of the earth is hotter than other regions. Air of this belt thus becomes lighter and rises up. Cold air from North and South rushes to take up the place of the hot air. Due to the rotation of the earth from West to East, this natural air current actually flows from the North-East direction in the northern hemisphere and from South-West direction in the southern hemisphere. These are called trade winds.

Land is a better absorber of heat and has a higher thermometric conductivity than water. Consequently land attains a higher temperature during the day time in comparison to the water. Air over land becomes lighter and rises up. Cold air from seas, oceans or lakes rushes to the land. This is called sea-breeze.

As a body which is a good absorber of heat is also a good radiator of heat, so in night the temperature over land goes on falling down much earlier than that over the water. Air over water being hotter rises up and cold air from land flows into the sea. This is called land breeze.

(iv) To fillup inert gases inside the electric bulbs : To avoid the burning of the filaments of the electric bulbs which are made of tungsten (high atomic wt. and high m.p.) the bulb is evacuated (creation of vacuum). Also to avoid the melting of filaments in the bulb some inert gases like argon or krypton are filled up and thus thermal radiations generated by filaments form a convectional current inside the bulb and a tremendous quantity of thermal energy produced doesn't melt the filament.

(C) Utilities and applications of radiation

(i) Cloudy night of winter is warmer than that of night of free and clear sky : In the night of free and clear sky the thermal energy (thermal radiation) produced from the earth's surface goes upwards uninterruptedly into the space through the sky. But during cloudy nights these radiations do not go into the space as the cloud is a bad conductor of heat which prevents these radiations get reflected back and our surrounding becomes warmer.

(ii) In desert area day is too hot and night is too cold : Since sand (silica) is a good absorber of thermal radiations and by Kirchhoff's law a good absorber of heat is also a good emitter (radiator). During the day the sand absorbs the thermal radiations from the sun and so day becomes too hot but at night all such radiations are emitted thus night becomes too cold.

(iii) Outer layers of a tea container (jar) are made bright : The bright layer neither permits inner thermal energy to go out nor absorbs or accepts outer thermal energy (radiation). It simply reflects and thus the container remains hot a longer time.

Prevost's theory of heat exchange : The most basic and fundamental concept about the radiation process was propounded by Prevost at Geneva in 1792. Before this theory it was assumed that there are two types of radiations – hot and cold. Cold bodies emit cold radiations and hot bodies emit hot radiations. A block of ice was supposed to emit cold radiations, because it produces a sensation of coldness and a red hot iron ball was supposed to emit hot radiations, as it produces the sensation of warmness. If this is a fact then there must be a basis to define hot and cold bodies. But we have no such basis of thinking and no scientific background. The correct explanation was given by Prevost.

Prevost asserted that all bodies, irrespective of their temperature, emit only one type of radiation and temperature is the only core factor regarding its rate of emission. At low temperature, the total emission (radiation of all wavelengths) is poor and at high temperature the emission of radiation is very high. The rise or fall of temperature, which is observed in a body is due to its exchange of radiant energy with surrounding bodies, which goes on uninterrupted in equal amount even after the attainment of thermal equilibrium. This is called Prevost's theory of heat exchange. When we stand near a fire, we have the sensation of warmness, because our body which is also a radiator receives more energy from the fire than what it loses through radiation. But when we stand near a block of ice, we feel a sensation of coldness because our body emits more radiant energy than what it receives from the ice.

By the devices pyrometers and bolometers the thermal radiations were detected earlier but at present thermopiles are the appropriate devices operated on the basis of variation of temperature with resistance of platinum wires. Thus, the temperature of the sun, stars etc. can be measured by pyrometers and bolometers.

4. Kinetic theory of gases

The theoretical analysis of the behaviour of gases was first explained by J. Bernoulli in 1738. Later, Maxwell, Boltzmann and Clausius consensusly and comprehensively gave the theory of the nature, character and behaviour of gases and propounded various models and consequently a theory was concluded which is called kinetic theory of gases. The following assumptions (postulates) were given as below—

(i) Each and every particle of gases has identical mass and volume and these particles are called molecules.

(ii) The molecules of the gas are in random motion and they obey Newton's laws of motion. The molecules move in all directions with all possible velocities from zero to infinity and collide constantly with each other. Collision also takes place on the walls of the container. Though the molecules are constantly having their velocities changed in magnitude and direction due to mutual collisions, yet a particular temperature and its overall distribution in volume element remains unaffected.

(iii) The volume of the molecules is negligibly small in comparison to the volume occupied by the gas.

(iv) The collisions are perfectly elastic and are of negligible duration. The collisions of the molecules occur to each other and with the walls of the container in which both momentum and kinetic energy remain constant. The time of the collision is negligible in comparison to the time spent in traversing the paths between two collisions.

(v) The gas exerts pressure on the walls of the container. This pressure arises due to collisions of the molecules with the walls. As a molecule collides, it suffers a change in momentum. The rate of change of momentum is equal the force exerted on the wall (Newton's Second law of motion). Since a ge number of molecules collide frequently, they exert a steady force given by the average rate of change of momentum. This force measured per unit area of the wall is called the 'pressure' of the gas.

The pressure exerted by the gaseous molecules on the walls of the container = $p = \frac{1}{3} \rho \bar{C}^2$

where ρ = density of the gas

$\bar{C}^2$ = mean-square speed.

5. Thermodynamics

Thermodynamics is that branch of Physics in which we are mainly concerned about the transformation of heat into mechanical work. With the advancement of time thermodynamics covers all the branches of Physics as well as Chemistry and we deal now today a relationship between the heat and energy associated with any form of energy like-electrical, mechanical, chemical etc. Thus, thermodynamics is an emprical or experimental science and the laws of thermodynamics have been developed by means of observation and experiments since long.

Thermodynamic system : A thermodynamic system is one which may interacts with its surroundings in at least two distinct ways and one of these is necessarily a transfer of heat in or out of the system. The other may be some other means of transfer of energy, say by performance of mechanical work by or on the system or through electromagnetic interaction such as magnetisation.

Example: A gas contained in a cylinder, a vapour in contact with its liquid, a stretched wire, tyre containing air etc. are examples of thermodynamical system.

Thermal equilibrium : A thermodynamic system is said to be in thermal equilibrium if all parts of it are at the same temperature and this temperature is the same as that of the surroundings.

Zeroth law of thermodynamics : If two independent thermodynamical systems are in thermal equilibrium with a third thermodynamical system, then they must be in thermal equilibrium to each other. This is called Zeroth law of thermodynamics and it becomes a base for the definition of temperature. All these systems can be said to possess a characteristic to remain in thermal equilibrium and this characteristic is called temperature. Thus, we can define the temperature of a system as the property by virtue of which we determine whether the system is in thermal equilibrium or not with other neighbouring systems.

Mechanical equilibrium : For a system (thermodynamical) to be in mechanical equilibrium, there must be no unbalanced forces between different parts of the system or between the system and the surroundings.

Chemical equilibrium : For a system to be in chemical equilibrium, the composition of the system must remain fixed (constant) and system must have a definite physical configuration.

Thermodynamical equilibrium : If a thermodynamical system is in thermal equilibrium, mechanical equilibrium and chemical equilibrium then the system is said to be in thermodynamical equilibrium. In the condition of thermodynamical equilibrium no change occurs in the state of system or in the surroundings.

Thermodynamical definition of Ideal gas (perfect gas) : An ideal gas (perfect gas) is one whose internal energy is entirely kinetic and depends on its temperature only and it is independent of its volume. This definition has been concluded from Joule's experiments which simply showed that there is no intermolecular attractions among the gaseous molecules. Thus, total internal energy is entirely kinetic and it depends upon the temperature only.

Thermodynamical definition of real gas : A real gas has intermolecular attractions among gaseous molecules and thus the internal energy is both potential and kinetic. Thermodynamically real gas is called Vanderwaal's gas whose nature, character and behaviour are determined by Vanderwaal's gas equation $(p + a/v^2)(v - b) = RT$, where a, b are called Vanderwaal's constants.

First law of thermodynamics : The first law of thermodynamics is simply the law of conservation of energy applied to the thermodynamical system. According to this law if a substantial amount of thermal energy is supplied to a thermodynamical system, then it is partially used in changing its internal energy (temperature dependent) and partially used in doing external work.

If dQ is the thermal energy supplied and dU and dW are change in internal energy and external work done respectively, then according to the First law of thermodynamics.

$$dQ = dU + dW.$$

All are expressed in same unit and it is called differential form of the First law of thermodynamics.

In thermal physics practically all mechanical works can be transformed into thermal energy (heat energy) but its converse is not true. The First Law of thermodynamics simply explains it, as equivalency of both mechanical work and quantity of heat being extracted mutually and nothing else.

Second law of thermodynamics : To extract a certain quantity of heat from a body and to convert it completely into work is permitted by the First law of thermodynamics. But in actual practice it is found to be impossible. If this was possible, we could drive ships across an ocean by extracting heat from the water of the ocean. Thus the First law simply tells that if a process takes place, energy will remain conserved. It doesn't tell us whether the process is possible or not. Similarly, if a hot body and a cold body are brought in contact, the First law is not violated whether the heat flows from hot to cold or cold to hot. But experience has shown that heat never flows from cold to hot body.

The Second law of thermodynamics explains the possibility of the thermodynamical process, its direction and its relevancy. In this regard two important statements are given :

Kelvin-Planck's statement : It is impossible to construct a device which operates in a cycle that will take heat from a body and convert it completely into the work without leaving any change anywhere.

Clausius's statement : It is impossible to construct a self acting device which operates in a cycle that will transfer heat from a cold body to a hot body without expenditure of work by an external energy source or without any aid of external agency. In other words heat cannot flow spontaneously from a colder to a hotter body.

Third law of thermodynamics : The entropy of any system at absolute zero (lowermost temperature) is a universal constant, which may be taken to be zero. This is called Third law of thermodynamics or *Nernst heat theorem.*

Here two important consequences of this law are :

(i) Specific heat capacities of a system vanish at absolute zero.

(ii) Coefficient of volume expansion of any substance vanishes at absolute zero.

An alternate statement of third law of thermodynamics is the unattainability of absolute zero. A fundamental feature of all cooling processes is that if the temperature achieved is lower, it is difficult to go still lower. Thus, Third law of thermodynamic can also be stated as it is impossible to reduce any system to the absolute zero by a finite number of operations by any procedure, no matter how the system is idealised.

Entropy : If a substance takes or gives up an amount of heat Q in a reversible process at constant temperature T, then $\frac{Q}{T}$ is called an increase or a decrease in the entropy of the substance. Thus change in entropy is denoted by $\Delta S = \frac{Q}{T}$. Obviously its SI unit is Joule/kelvin and its C.G.S. unit is Cal/kelvin. But the Second law of thermodynamics imposes the restriction in which only those processes are possible for a system in which entropy of the system plus surroundings always increases. Thus, on account of the processes occurring in nature the entropy of the universe is continuously increasing. That's why entropy doesn't obey the law of conservation.

Our every day experience tells us that chaos (disorder) must probably exist in nature as usual while the orderness is the least probable. Thus, in all natural processes there is a tendency to proceed towards a state of great disorder. As entropy of a system increases due to natural process taking place in the system, the degree of molecular disorder of the system also increases. Thus entropy of a system is a measurement of the degree of molecular disorder existing in the system. That's why we conclude that gas has more entropy than liquid and liquid has more than solid.

i.e. $(\text{gas})_{\text{entropy}} > (\text{liquid})_{\text{entropy}} > (\text{solid})_{\text{entropy}}$.

Some important thermodynamical processes

(i) Cyclic process : The thermodynamical system which operates in such a way that its initial and final conditions are the same, then it is said to be in a cyclic process.

By the First law of thermodynamics

$dQ = dU + dW = U_f - U_i + dW = dW \quad (\because U_f = U_i)$

Thus, total thermal energy would be utilised in doing mechanical work and change in internal energy would be zero.

(ii) Quasi-Static process : A process in which a system never works more than infinitesimal (very small) from the equilibrium state and it is called a quasi-static process. Thus, the quasi-static process is an ideal process which can never be exactly obtained but can be approximated under some specific circumstances.

(iii) Reversible and Irreversible process : A reversible process is one which can be reversed in such a way that all changes taking place in the direct process are exactly repeated in the reverse order (opposite sense) and no changes are left in any of the bodies taking part in the process or in the surroundings. The conditions of reversibility are never realised in practice, hence a reversible process is only an ideal conception.

Any process which is not reversible exactly is an irreversible process. All natural processes such as conduction, radiation, radioactive decay etc. are irreversible processes. Thus, irreversibility is a rule.

(iv) Isothermal and Adiabatic process : When a thermodynamic system undergoes through a process in which its temperature remains constant, then the process is said to be isothermal. The essential condition for an isothermal process is that the system must be contained in a perfectly conducting chamber and it occurs extremely slowly in which the heat produced or absorbed during the process at once goes out or comes in from outside. Hence, temperature will remain constant but as there is no perfect conductor, so isothermal process cannot be performed exactly but can only be approximated. Ideal gas equation $PV = RT$ is directly applicable for an isothermal process.

But when a thermodynamic system undergoes a process under the condition that no heat comes into or goes out of the system, then the process is said to be adiabatic. Such process can occur when the system is perfectly insulated from the surroundings. But since no perfect insulator is available, perfect adiabatic change is impossible. Thereby, an approximate adiabatic process can be obtained (achieved). It is an extremely rapid or fast process because there is a very little time for the heat to go out or to come into the system. The equation PV^γ = constant is directly applicable and relevant for an adiabatic process, where γ = specific heat capacities ratio of the ideal gas.

Examples : If a gas is suddenly compressed, the heat of compression is added to its internal energy and its temperature rises. That's why the bicycle pump is heated when the air in it is suddenly compressed. Similarly, if a gas is suddenly expanded, then the external work done during it against the surroundings draws energy (equivalent to the work done) from its internal energy and its temperature falls. When a motor tyre bursts, the sudden expansion of air into the atmosphere is an adiabatic process in which the tyre is cooled down. As in an adiabatic process no heat exchange takes place, so entropy also remains constant. That's why the adiabatic process is also called isentropic (constant entropy) process.

To prepare dry ice (solid CO_2) carbon dioxide is suddenly expanded and consequently it converts into ice, called dry ice.

On shaking a thermos containing tea becomes warm, because on shaking the existing viscous forces among various layers of the tea do external works and these works are transformed into thermal energy. So its internal energy increases and consequently the temperature rises.

(v) Isobaric and Isochoric process : A thermodynamic process taking place at constant pressure is called an isobaric process.

Example—The boiling of water to steam or the freezing of water to ice taking place at a constant pressure (also at constant temperature) are isobaric processes.

A thermodynamic process taking place at constant volume is called isochoric process. Obviously, in such a process the work done on or by the process is zero ($dW = 0$).

Thus, in an isochoric process, the heat added to (or taken from) the system only increases or decreases the internal energy of the system.

If an ideal gas is assumed to be a thermodynamic system, then work done by the gas or on the gas are different for different processes and which can be compared as given below;

$$W_{\text{Isobaric}} > W_{\text{Isothermal}} > W_{\text{Adiabatic}} > W_{\text{Isochoric}} \rightarrow \text{Thermal Expansion.}$$

$$W_{\text{Isochoric}} > W_{\text{Adiabotic}} > W_{\text{Isothermal}} > W_{\text{Isobaric}} \rightarrow \text{Thermal Compression}$$

Miscellaneous topics

(I) Cooling process (Mechanism)

(a) Evaporation (Vaporisation) : From the outer surface of any liquid at any temperature slowly and steadily the transformation of liquid into vapour is called *evaporation*. In the process of evaporation (vaporisation) the heat energy is supplied by the inner molecules of the liquid and when a sufficient heat energy is acquired by the molecules of outer surface then these molecules start to detach from the liquid. Thus, vapour is formed and along with themselves molecules have lower heat energy and ultimately temperature falls. Thus evaporation is a process of obtaining the cooling from the liquid. The evaporation depends on various factors like amount of vapour present in atmosphere, the area of the liquid surface, the temperature of the liquid etc. If the water vapour present in the atmosphere is large then the rate of evaporation is least and vice-versa. That's why in summer wet clothes are dehydrated soon and made dry in short interval of time, while in rainy season the process of drying takes a longer time. In summer, surahi (water container made of ceramic) by the evaporation process lowers the temperature and water becomes cool. If the body temperature of a man/women due to suffering of a severe fever becomes extremely high then on keeping the weted cloth on his/her forehead such high temperature can be lowered down through the process of evaporation.

A room/hall or any closed space (region) cannot be cooled down by opening the door of the refrigerator but ultimately it will be warmed up. As the refrigerator removes heat from its interior and expels it into the surrounding air, it ultimately warms up the room/hall or closed space.

The refrigerator also produces cooling by the process of evaporation. In the process of refrigeration the liquid freon is filled up in the vapoured coil of copper and by the process of evaporation cooling is achieved.

(b) Adiabatic Demagnetisation : At present by the mechanical process the lowest temperature is obtained by the method of adiabatic demagnetisation. When a paramagnetic substance is magnetised, its molecules are set in the direction of the magnetising field. The necessary work done in this process is added to the internal energy of the substance which suffers a rise in temperature. If the substance is allowed to cool and then demagnetised under an adiabatic condition, the molecules return to their original random distribution and there is a corresponding fall in temperature. This effect is too much pronounced at a very low temperature.

Giauque and McDougall used gadolinium sulphate (a paramagnetic salt) and a magnetic field of 8000 Gauss in order to obtain the temperature of 0.25 *K*.

(c) Joule-Thomson (Joule-kelvin) effect : Joule and Thomson experimentally observed that when a gas under constant pressure is forced through an insulated porous plug (compressed porous material like cotton-wool or silk fibres) to a region of lower constant pressure, its pressure changes. This is called *Joule-Thomson effect*. All gases when pass through the porous plug, suffer a change in temperature and this temperature change is directly proportional to the pressure difference of two sides of the plug. At ordinary temperature all gases, except hydrogen and helium, suffer a fall in temperature (cooling effect), while hydrogen and helium suffer a slight rise in temperature (heating effect).

The temperature of inversion $\left(T_i = \frac{2a}{Rb}\right)$ is characteristic of the particular gas and below this temperature cooling is observed, while above it heating is observed and at the inversion temperature neither heating nor cooling takes place.

The inversion temperatures for H_2 and He are − 80°C and − 240°C, hence these gases show heating effects at ordinary temperature. If the initial temperatures of H_2, He is brought below − 80°C and − 240°C these gases will also show cooling effect.

(d) Adiabatic expansion : If a compressed gas is suddenly released to the atmosphere, then it does an external work against the molecular attractions. Since the expansion is sudden and no appreciable amount of heat flows into it from the surroundings, the external work is drawn from the internal energy of the gas itself which therefore cools. Thus, in adiabatic expansion the cooling is mainly due to the external work done.

Four processes are common to achieve the cooling and the chronological order of the processes of these cooling are; adiabatic expansion, evaporation, Joule-Thomson effect and adiabatic demagnetisation in their increasing order.

i.e. (adi. demag.)$_{\text{cooling}}$ > (Joule-Thomson)$_{\text{cooling}}$ > (evaporation)$_{\text{cooling}}$ > (adi. expan)$_{\text{cooling}}$

(II) (a) Humidity : The amount of water vapour present in the atmosphere is called humidity. The amount of water vapour in atmospheric air is different for different places. Generally, the amount of water vapour near the sea-level is large thus, humidity is also large. In rainy season usually humidity is found to be more.

(b) Relative humidity : The relative humidity is the ratio of the amount of water vapour in the air of a given volume at a particular temperature to the required water vapour in air to saturate the same volume at the same temperature.

$$\text{Thus, relative humidity} = \frac{\text{The water vapour in air of any volume at any temperature}}{\text{The water vapour required of the same volume at the same temperature}}$$

The relative humidity is measured by a device called *Hygrometer.* On increasing temperature relative humidity is increased.

Saturated vapour : If at a given temperature air absorbs a definite amount of water vapour, then at this state air is said to be in the state of saturated water vapour.

(c) Air-conditioning : The climate of any place on the earth's surface is determined by various parameters like temperature, relative humidity, the wind flowing direction etc. Usually for a hygienic and comfortable climate the following conditions should be fulfilled.

(i) The temperature should lie between 23°C to 25°C.

(ii) The relative humidity should lie between 60% to 64%.

(iii) The speed of wind should lie between 0.0125 m / sec to 0.01417 m / sec.

Such climate usually doesn't exist naturally specially in the urban areas. Thus it is prepared artificially and on this principle air-conditioning operates.

IV. Light

1. Nature and Speed of Light

Light : Light is an external cause due to which any object becomes visible for human eye. For the illumination or visibility of an object light incidents upon it (up to 1/6th second). Then after reflection it comes to the eye and then the object is seen. At present light is defined in the form of an energy which transmits (propagates) as an electromagnetic wave and whose energy is confined in the form of a small packet called photon.

Dual nature of light : In early time it was believed that light consists of a stream of corpuscles, emitted by various light sources travells outward from the sources in straight lines. This was the idea of Newton's Corpuscular theory. The corpuscles directly penetrate through the transparent materials but reflect back from the surfaces of opaque materials. When they (corpuscles) enter the eye, they cause the sense of illumination.

But during the middle of 17th century the idea of light as a wave was perceived. Huygens in 1670 showed that the laws of reflection and refraction could be explained on the basis of wave theory. But it was objected that if the light exhibits the wave motion, then one should be able to expose it around the corners, as waves can bend around the obstacles in their path. It is well known that the wavelengths of light waves are so small that on the bending, which actually takes place is so small that it is not ordinarily observed. In fact, the bending of light waves around the edges of an object (a phenomenon called diffraction) was noted by Grimaldi before 1663 and interpreted by Hooke in 1665 in terms of wave picture, but its significance was not recognized at that time.

After 1827 the experiments of Young and Fresnel on the interference and the measurement of the velocity of light in liquids by Foucault demonstrated the phenomenon which could not be correctly explained by the corpuscular theory, and it could be explained only by the wave theory. Young's experiments enabled him to measure the wavelength of the waves and Fresnel showed that the rectilinear propagation of light as well as the diffraction observed by Grimaldi and others, could be explained if light is assumed to be waves of shorter wavelength.

The next forward step in the theory of light was taken by Maxwell who showed theoretically that an oscillating electrical circuit radiates electromagnetic waves propagating with the velocity of light. Approximately fifteen years later, Hertz succeeded in producing short-wavelength waves of electromagnetic origin and showed that they possessed all the properties of light waves like reflection, refraction, polarisation etc. Thus, Maxwell's electromagnetic theory of light was experimentally verified. But unfortunately the phenomenon of photoelectric effect (the ejection of electrons from a metallic conductor by the incident of light on its surface), Compton's effect, Raman effect etc. couldn't be explained on the basis of wave theory. Einstein explained these on the basis of Plank's quantum theory

At present the dual nature of light (both as a wave and a particle) is acceptable. The phenomenon of propagation of light may best be explained by the electromagnetic wave theory, while the interaction of light with matter in the process of emission and absorption is a corpuscular phenomenon.

Speed of light : Firstly Romer (an astronmer) obtained the value of the speed of light with the help of motion of the sattelite of the planet (Jupiter). In different media the speeds of light are different and it depends upon the refractive index of the medium. The medium which has larger refractive index has smaller speed of light.

The refractive index or index of refraction $(\mu) = \dfrac{\text{speed of light in vacuum}}{\text{speed of light in medium}}$

The speed of light is maximum in vacuum and it is 3×10^8 meter/sec. (1,86,310 mile/sec or 2, 99,776 km/sec). In any denser medium the speed of light is always smaller than that of vacuum. In air the value of the speed of light is 0.03% lesser than the value of the speed of vacuum, in water it is smaller than 25% and in glass it is lesser than 35%.

Values of the speeds of light in various media

Medium	Speed of light (m/s)	Medium	Speed of light (m/s)
Vacuum	3×10^8	Glass	2×10^8
Water	2.25×10^8	Rock salt	1.96×10^8
Oil of tarpin	2.04×10^8	Nylon	1.96×10^8

Light from the sun reaches the earth's surface in 8 minutes 19 seconds and the reflected light from the moon takes 1.28 seconds to reach the earth's surface.

Rectilinear propagation of light : In an isotropical (having same density) materialistic medium the rays of light move in straight line. This is called rectilinear propagation of light. The formation of various types of shadows, the formation of image through a pin hole camera, occurrence of solar and lunar eclipses etc. are the examples of rectilinear propagation of light.

Miscellaneous

(i) Firstly Newton asserted that light is made of micro particles or corpuscules and it moves in a straight line. Newton also speculated that white light is made of all the seven colours.

(ii) Huygens propounded the wave theory of light. Which asserted that light can be displayed in the form of waves.

(iii) Young propounded the theory of Interference of light. Young's experiment was the base of the verification and confirmation of wave theory for the physicists.

(iv) Maxwell propounded the theory of electromagnetism in 1864. According to Maxwell the oscillating electric and magnetic fields generate an electromagnetic wave perpendicular to each other and its direction of propagation is perpendicular to each electric and magnetic field. This theory was verified by Hertz and later on commercial level too much work was done by Marconi in this regard.

(v) Max. Planck in 1900 gave the famous quantum theory by the help of an equation $E = h\nu$, where h is called Planck's constant and ν is the frequency of emitted photon. He also explained that the energy in the electromagnetic wave is quantized and appears descretly in the form of packet called quantum and this energy is confined in the form of a pocket called photon. This concept became the origin of Quantum mechanics later.

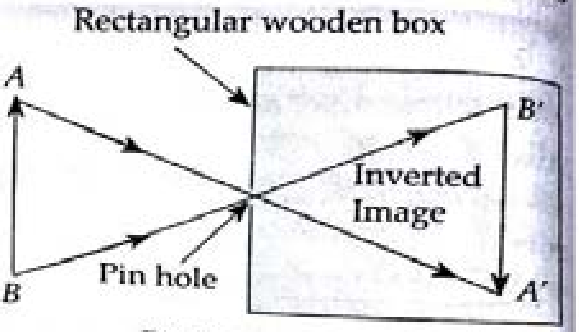
(vi) Einstein on the basis of a comperhensive observation and speculation in 1905 declared that the light is quantized and the energy is divided into a small group called quanta and the corpuscule of the light is called photon.

Sources of light : The sun, stars and other celestial bodies in our universe are the natural sources of light. In stellar or solar system, hydrogen atoms regularly transform themselves into helium and tremendous amount of solar energy or stellar energy is produced.

Apart of such energy is received by our earth's surface. The sun is supplying 4×10^{26} Joule energy per second and according to Einstein's mass energy equivalent relation ($E = mc^2$), the rate of mass decay is 4×10^9 kg/sec. It is predicted that our sun will supply its energy upto approxmately one thousand crores years. There are some artificial sources of light like electric bulbs, matches, candles etc.

Shadow : When an opaque body (body through which light rays are obstructed on passing) is placed in the front of a source of light, then behind the opaque body a black or dark region appears which is called shadow. The formation of shadows depends on the types of source of light. If the source of light is a point source, then the shadow formed is called umbra while for an extended source of light is called *penumbra.*

Pin hole camera : In it a rectangular wooden box whose inner walls are painted black and a pointed hole is made in the front wall of the box and rear wall has a cover of rubbed glass or a piece of oily paper are taken. Whenever an object is kept in front of a camera then an inverted image is formed near the rear wall of the box. If more than one pointed hole is made in the front wall, then a number of inverted images are formed which are equal to the number of holes.



Pin hole camera

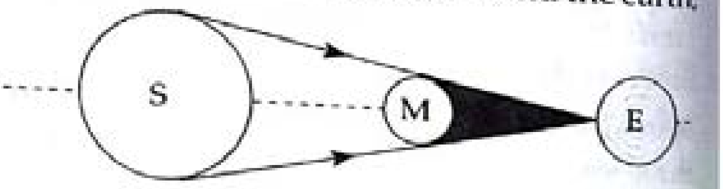
This also proves the rectilinear propagation of light. The size of image depends on the distance between the pointed hole and screen and the distance between the object and the pointed hole. If on behalf of the screen the photographic plate is taken, a distinct and decent (perfect) image is formed.

$$\text{Here, magnification} = \frac{\text{Height of the object}}{\text{Height of the image}} = \frac{\text{Image distance from the hole}}{\text{Object distance from the hole}}$$

Obviously, for a substantial magnification the object distance from the pointed hole should be small.

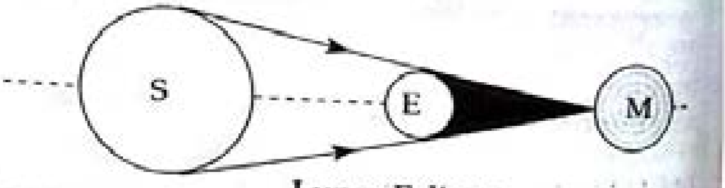
Eclipse :

(A) Solar Eclipse : When the moon comes between the sun and the earth, then the shadow of the moon falls upon the earth and from the shadow region the sun is not visible and this position is called *solar eclipse.* This eclipse may be full or partial. Full solar eclipse occurs on the day of *full moon.*



Solar Eclipse

(B) Lunar Eclipse : When the earth comes between the sun and the moon, then the shadow of the earth falls on



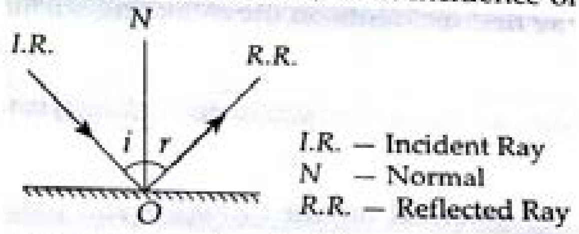
Lunar Eclipse

the moon then the shadow region of the moon is not visible and this position is called *lunar eclipse*. This eclipse may also be full or partial. Full lunar eclipse occurs on the day of *new moon*.

Eclipses are not visible and do not occur each and every month because the equatorial orbit of the earth makes an angle of 5° to 7° from the axial axis of the moon.

2. Reflection of light

When a light ray incidents on a smooth and polished surface, then it undergoes (comes) back almost in a different direction, such incidence of light ray is called reflection of light. A plane mirror is assumed to be the best reflector. The straight line perpendicular to the reflected surface is called normal. The angle between incident ray and normal is called angle of incidence and between the normal and reflected ray is called angle of reflection.



There are two laws of reflection—

(i) Incident ray, normal and reflected ray all lie in the same plane.

(ii) Angle of incidence and angle of reflection both are equal. Thus $i = r$

Plane mirror : One surface of the mirror is plane and another surface has a sharp metallic polish which is pasted. This is done to avoid the polish decay. The backside of the mirror with silver or mercury layers (metallic polish) works as reflector surface. The object and image both are located at equal distance. In a plane mirror the formed image is always imaginary and it is equal to the size of the object laterally inverted.

Some more facts related to plane mirrors

(i) If a body having a speed v moves forward with this speed then its image through a plane mirror appears to be moving with speed $2v$.

(ii) For showing the full image of an object, the size of the plane mirror should be at least half of the object.

(iii) If the incident ray is kept constant and the plane mirror is rotated by an angle θ, then the reflected ray is rotated by angle 2θ.

(iv) If two plane mirrors are inclined to each other at an angle θ, then total number of images formed between the two mirrors $= \dfrac{360^\circ}{\theta^\circ} - 1$.

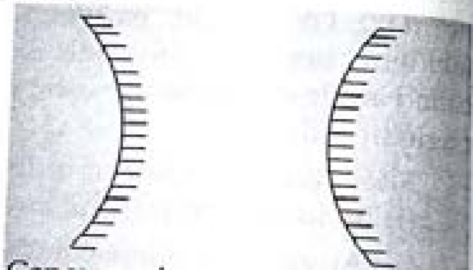
Thus, if two plane mirrors are inclined at right angle to each other then three images will be formed between them. Similarly, between two parallel plane mirrors infinite images would be formed.

Utilities : The plane mirror is utilised in the form of kaleidoscope, periscope, looking glass etc.

(i) Kaleidoscope : In it three rectangular plane mirrors of equal length and equal breadth are attached to each other in such a way that the angle between two mirrors is of 60°. The reflecting surfaces of all these mirrors are inwardly confined and in the space confined by the mirrors, the pieces of the colour glasses are kept. These three mirrors are kept inside a thick long pipe. The spherical piece of glass is attached to the first end of the pipe and at another end the piece of rubbed glass is attached. When we look inside the pipe through the transparent glass end, then on rotating the pipe new colour images are seen. These images are of the pieces of the colour glasses, which have been formed due to the multiple reflections of the plane mirrors. On moving the pipe location of the pieces of the colour glasses and the colour of images are changed.

(ii) Periscope : In it two plane mirrors are attached to each other at 45° in such a way that the reflecting surfaces are oppositely directed. Light ray first incidents on the reflecting surface of the first (upward) mirror and the reflected beam now incidents upon the second (downward) mirror so that after reflection it enters the eye. That's why during war time the arms uses periscope to detect the enemies who are hidden in bunkers. Also in submarines periscopes are frequently used today.

Spherical mirror : In spherical plane the constructed mirror is called spherical mirror in which one side of the mirror has a layer of mercury or coating of lead oxide. A thin layer is painted and pasted to one side and another side is used as a reflecting surface.

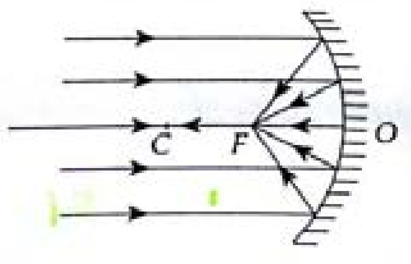


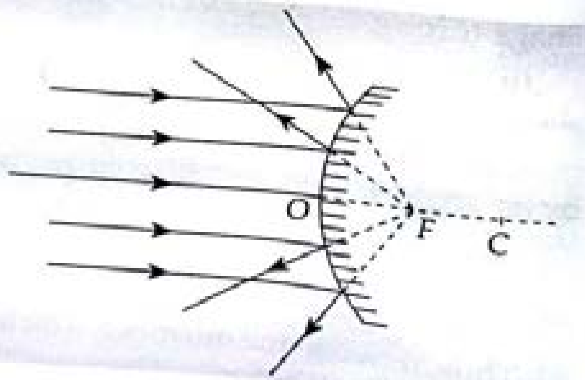
Concave mirror Convex mirror

The spherical mirror is of two types—

(i) Concave mirror : The spherical mirror whose reflecting surface is inwardly leaned is called concave mirror. It is also called converging mirror because it converges the coming rays from infinity.

(ii) Convex mirror : The spherical mirror whose reflecting surface is outwardly leaned is called convex mirror. It is also called diverging mirror because it diverges the rays coming from infinity.





As both concave and convex mirrors are constructed through the same spherical glass.The centre of the glass sphere is called centre of curvature (C) and the middle point (O) of the spherical mirror is called pole. The line passing through the centre of curvature and pole is called Principal axis. The middle point of the straight line drawn from the pole to the radius of curvature is called focus (F).

Thus focal distance $(f) = \dfrac{\text{radius of curvature}}{2}$

The focal distance (f) of concave and convex mirrors is evaluated by the following formula

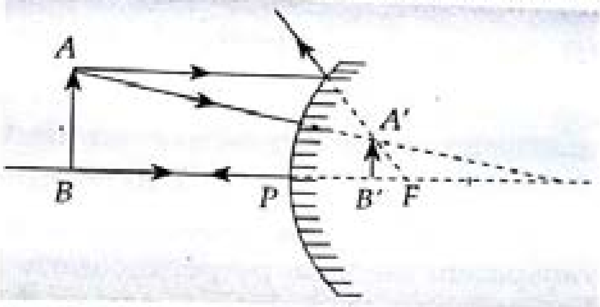
$$\frac{1}{v}+\frac{1}{u}=\frac{1}{f}$$

where u = Object distance
v = Image distance
f = Focal length of the mirror.

Magnification : The ratio of image distance to object distance or the ratio of the length of image to the length of the object is called magnification of the mirror and is represented by m.

$$\text{Thus magnification } (m) = \frac{\text{Length of Image}}{\text{Length of object}} = \frac{\text{Image distance } (v)}{\text{Object distance } (u)}$$

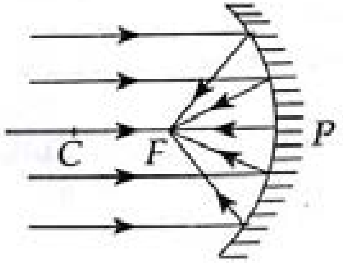
The image formed by convex mirror : In convex mirror the image of an object is formed behind the mirror between the pole and the focus and the image formed is smaller than the object and it is erect and virtual.



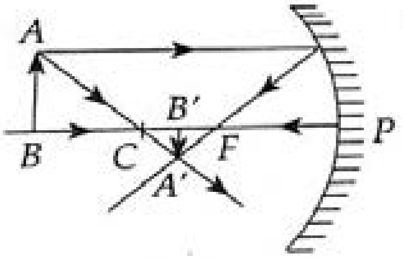
If the position of the object is changed and if it shifts from the pole, then the virtual erect image becomes smaller and shifts towards the focus.

Use : Since convex mirror is diverging in nature, so the objects of a large region are being diverged into a smaller region. That's why the convex mirror has a vast field-view and so these mirrors are utilised in motor cars, trucks etc. as a rear view mirror. Due to large field view these are utilised in the reflecting lamps installed near the roads and streets.

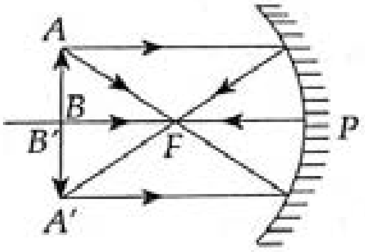
The images formed by concave mirror : The position of the object may vary according to our choice and so the images which are real and inverted can be formed at various locations tabulated as given below.



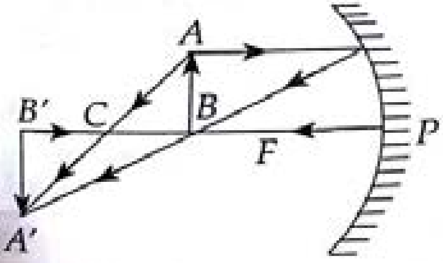
(a)



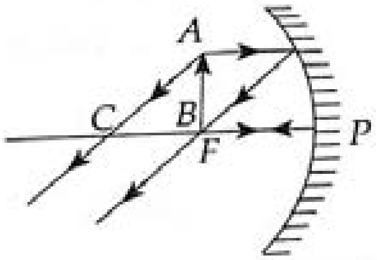
(b)



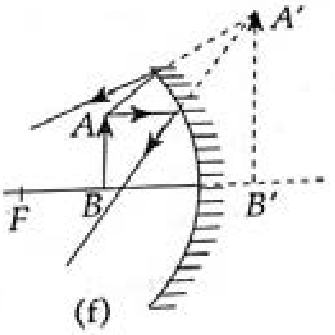
(c)



(d)



(e)

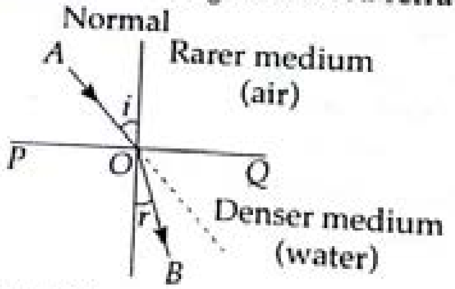


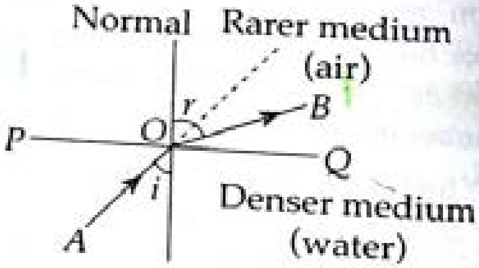
(f)

Position of object	Position of image	Size of image with comparison to object	Nature of imag
(a) At infinity (∞)	At focus	Very small	real and inverted
(b) Between centre of curvature and infinity	Between focus and centre of curvature	Small	real and inverted
(c) At centre of curvature	At centre of curvature	Equal in length	real and inverted
(d) Between focus and centre of curvature	Between centre of curvature and infinity	Large	real and inverted
(e) At focus	At infinity (∞)	Very large	real and inverted
(f) Between pole and focus	Behind the mirror	Large	virtual and erected

3. Refraction of light

When a light ray passes from one transparent medium to another transparent medium perpendicularly at any point on a line dividing both the mediums, then the ray passes directly without any deviation. But if they incident inclinedely then they deviate from the original path and this phenomenon of light is called refraction of light.





If a light ray enters from a rarer medium to a denser medium (say, air to water) then this ray leans towards the normal drawn on the dividing line of both the mediums, but in the reverse case it escapes far away from the normal. Also if a ray passes from any medium to any other medium parallel to the normal, then it also passes directly without any deviation.

Laws of refraction :

(i) Incident ray, Normal and Refracted ray all lie in the same plane.

(ii) For any two mediums the ratio of sine of the angle of incidence and sine of the angle of refraction is constant and it is called refractive index of second medium with respect to first and this statement is also called *Snell's law*.

Thus $\frac{\sin i}{\sin r} = \mu$ or ${}_1\mu_2$.

Now, if ${}_1\mu_2 = \frac{\sin i}{\sin r}$, ${}_2\mu_3 = \frac{\sin r}{\sin r'}$ and ${}_3\mu_1 = \frac{\sin r'}{\sin i}$

where; 1 → 1st medium, 2 → 2nd medium, 3 → 3rd medium then ${}_1\mu_2 \cdot {}_2\mu_3 \cdot {}_3\mu_1 = \frac{\sin i}{\sin r} \cdot \frac{\sin r}{\sin r'} \cdot \frac{\sin r'}{\sin i} = 1$, similarly; ${}_a\mu_w \cdot {}_w\mu_g \cdot {}_g\mu_a = 1$

Where 1 → air (a), 2 → water (w), 3 → glass (g)

If refraction takes place from vacuum or air to any medium then the above ratio of sine of angle of incidence and sine of angle of refraction is called absolute refractive index or simply index of refraction. This is Snell's law.

Thus, absolute refractive index $(\mu) = \frac{\sin i}{\sin r}$

It is also observed optically that the ratio of velocity of light in vacuum to velocity of light in any medium is equal to the absolute refractive index of the medium.

Thus; $\mu_0 = \frac{\text{velocity of light in vacuum } (c_0)}{\text{velocity of light in medium } (c_m)}$ i.e., $\mu_0 = \frac{c_0}{c_m}$

The refractive index of different colours (different wavelengths) of the light are different. On increasing wavelength refractive index decreases. That's why the red colour of visible light has the least value of refractive index and the voilet colour has the largest value of refractive index, as the red colour has longer wavelength and the violet colour has shorter wavelength. Also with rise in temperature index of refraction slightly decreases.

Some interesting incidents related to refraction of light :

(i) Twinkling of stars at night : Atmospheric air has various layers of different densities. Whenever light rays coming from stars incident on air surface (layer) then refract from various layers because air layers are not static. Thus we observe that stars are twinkling due to their various positions in different time intervals.

(ii) The coin kept at the bottom of a container having water seems upwardly uplifted : Whenever a coin is kept inside a water container, then the phenomenon of refraction takes place and the coin kept in the container seems upwardly uplifted.

(iii) A fish inside water seems uplifted from its original position.

(iv) A straight rod partially sunk inside water seems to be bent.

(v) Whenever the sun is below the horizon then before sunrise and after sunset the region around the sun appears red due to refraction.

4. Total Internal Reflection of light

When any light ray enters from an optically denser medium to an optically rarer medium then due to refraction the light ray bends away from the normal. But as well as the values of angles of incidence are increased, the light bending from the normal becomes more and more away. Thus, the value of angle of refraction is in increasing order. But for a definite angle of incidence the angle of refraction becames 90° and here the angle of incidence is called critical angle.

Thus index of refraction $(\mu) = \frac{1}{\sin C}$

$\Rightarrow \sin C = \frac{1}{\mu}$, where C = critical angle.

If the angle of incidence is increased by more than a certain value, then the light ray doesn't refract at all. Thus the angle of incidence can not be greater than 90°. In this situation incident light ray reflects back into denser medium and this incident in geometrical optics is called *total internal reflection.* Also the region (space) where the phenomenon of total internal reflection takes place becomes extremely bright.

Thus, for the occurrence of total internal reflection two conditions are required—

(i) The light ray must enter from an optically denser to an optically rarer medium.

(ii) The angle of incidence should always be greater than critical angle.

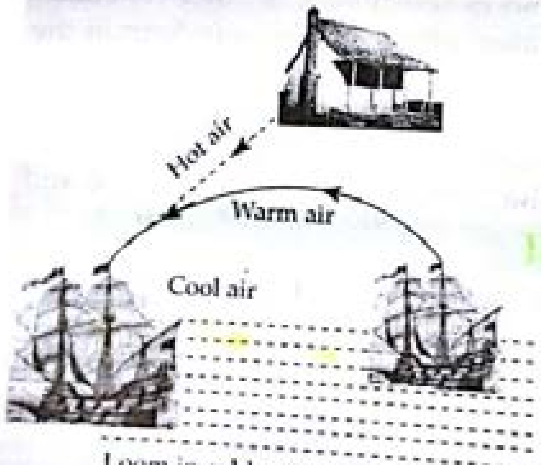
Critical angles of some important substances :

Substance	Index of refraction	Critical angles	Substance	Index of refraction	Critical angles
Water	1.33	48.5°	Flint glass	1.65	37.4°
Crown glass	1.52	41.1°	Diamond	2.42	24.4°

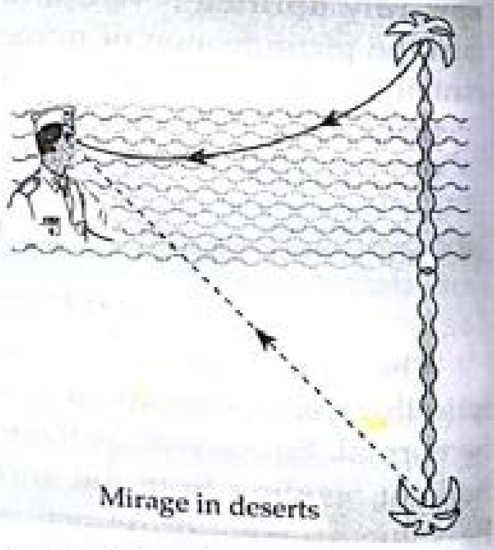
Some interesting incidents related to total internal reflection—

(i) Over brightness in diamond : The critical angle is very low (approximately 24°) for a light ray coming from diamond to air. When light rays enter into the diamond, then from various layers multiple reflections take place and if the angle of incidence of the rays becomes less than 24°C then light rays come out from the diamond. Thus, light rays entering from every side into the diamond, only appear to come from certain side and that's why the diamond appears overbrightend.

(ii) Ships hang inverted (looming) in the air in cold countries and trees hang inverted (mirage) underground in deserts :



Loom in cold countries



Mirage in deserts

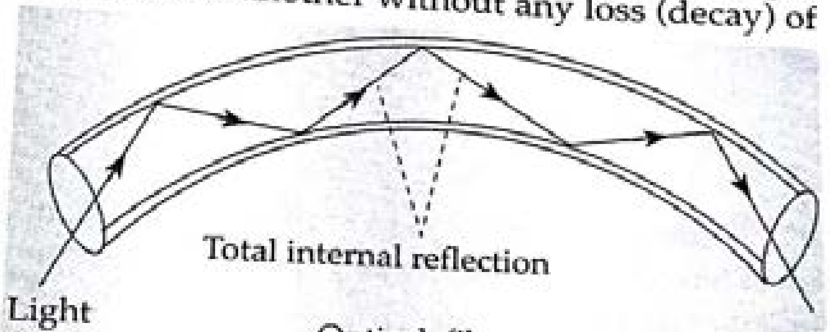
In cold countries air is found to be in the most densed state at the surface of sea-water and it gets gradually rarer upwards. So the rays diverging upwards from an object on the surface of sea-water say, a ship are refracted continuously away from the normal. Now it is totally reflected when the light rays begin to travel downwards with continuous refraction towards the normal and ultimately reaches the eye of the observer in the upward direction. That's why the ship appears inverted in air, and it is said to be the position of loom.

In deserts the situation is just the reverse. Here air is the rarest at the ground level and gets gradually denser as we go upwards. So the light rays diverging downwards from an object above the ground, say the leaf of a tree, are refracted continuously away from the vertical. Now it is totally reflected when the light rays begin to travel upwards with a continuous refraction towards the vertical and soon reach the eye of the observer in the downward direction. The leaf so appears underground and it is called *Mirage*. In fact, the ship and the tree are not inverted but they seem to be inverted. These are simply optical illusions.

(iii) The cracked part of glass appears to be brightend : The cracked part of glass contains air, which acts like a rarer medium with respect to it. When light rays enter through the glass (cracked) to air then they refract in which the angle of incidence becomes greater than the critical angle, and the phenomenon of total internal reflection takes place. That's why cracked part of glass appears to be brightend.

(iv) A test tube filled with water appears to be brightend due to the similar reason.

(v) Optical fibre : Rectilinear propagation of light which is a well known optical phenomenon and by the use of total internal reflection light can also be passed through the curved optical path. A fibre is an optical system based upon the basic principle of total internal reflection and through which light signal is transferred from one place to another without any loss (decay) of amplitude or intensity. An optical fibre is basically composed through a long, large and compact quartz fibre and each fibre is 10^{-4} cm thick. Around the optical fibre a substance whose index of refraction is about 1.6 is wrapped out. When the light rays incident on one side of this fibre by making a very small angle, then these are refracted inside it. Thus incident rays after being totally internally reflected collide with the other end of the fibre. On this limiting surface upto which optical fibre is confined again the angle of incidence becomes greater than the critical angle and total internal reflection takes place again.



Optical fibre

Thus, the phenomenon of total internal reflection takes place repeatedly and the light ray reaches from one end to another end.

Use of optical fibre :

(i) To send an electric signal by transforming it into a light signal and vice-versa.

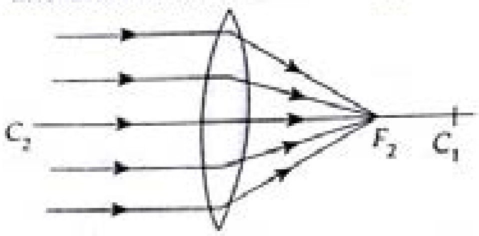
(ii) To send laser light rays inside the human body.

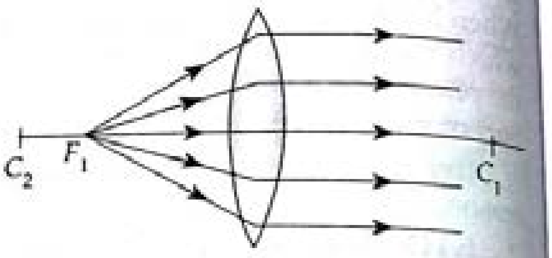
(iii) Today optical fibres are frequently used in telecommunication. Old copper cables are being replaced today by optical fibres whose capacity is large and they are convenient in use and which are noise free.

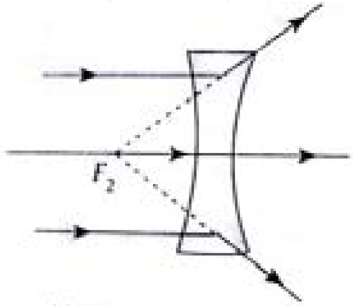
5. Refraction of light through a lens

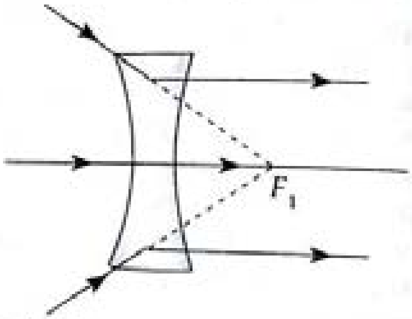
Lens : A lens is a transparent medium bounded by two spherical surfaces.

The line joining the centres of curvature of the two bounding surfaces is called principal axis of the lens. The section of a lens by a plane passing through its principal axis is called principal section of the lens. A lens is shown by its principal section. The point on the principal axis of the lens through which rays pass undeviated through the lens is called its *optical centre*. Lenses bound by two convex spherical surfaces are called *convex lenses* and those bound by two concave spherical surfaces are called *concave lenses*. Lenses which converge a parallel beam of rays to a point are said to be convergent in nature and those which diverge the rays from a virtual point are said to be divergent in nature. Generally, convex lenses are *convergent* and concave lenses are *divergent*.



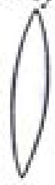




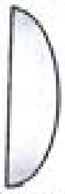


Under co-ordinate sign convention (which is updately acceptable) the focal length of the convex lens is taken positive and that of concave lens is taken negative.

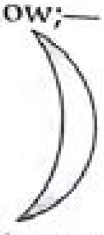
The lenses are generally constructed by the good quality hollow spherical glasses which act like refracting surfaces by various ways but only six types are common which can be shown as below;—



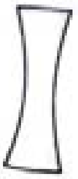
Convex lens or
Convexo-convex lens



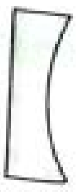
Plano-convex lens



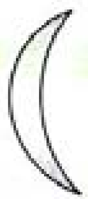
Concavo-convex lens



Concave lens or
Concavo-concave lens



Plano-concave lens



Convexo-concave lens

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convergent

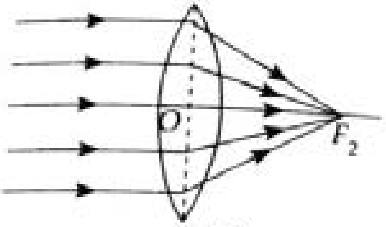
Terms related to lens

Optical centre : It is a mid point in a lens and any light ray which passes through it doesn't deviate.

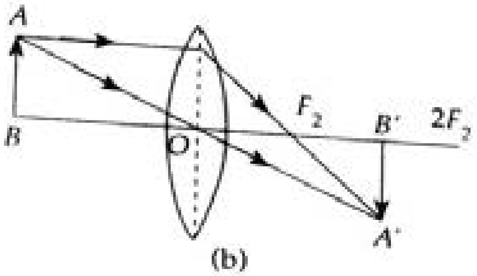
Focus : The point at which the light rays coming parallel to the principal axis meet or appear to meet after refraction is called focus.

Focal length : The distance between the optical centre and the focus is called focal length.

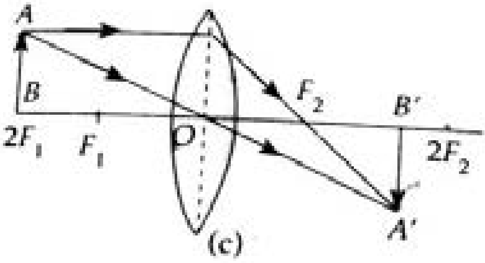
The Image formation by convex lens : The nature of image formed, its size and position etc. depend on the distance of the object kept from the focus. There may be following positional configuration in various cases given as below—



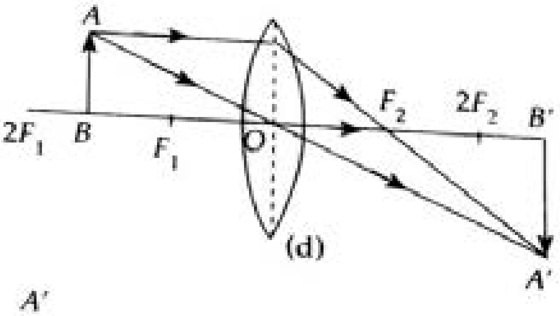
(a)



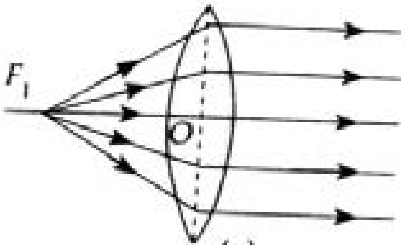
(b)



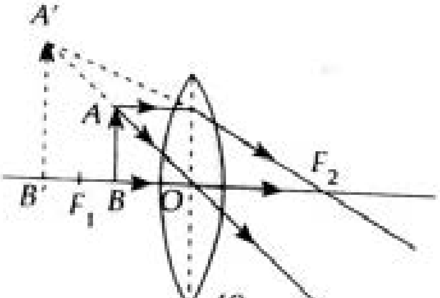
(c)



(d)



(e)



(f)

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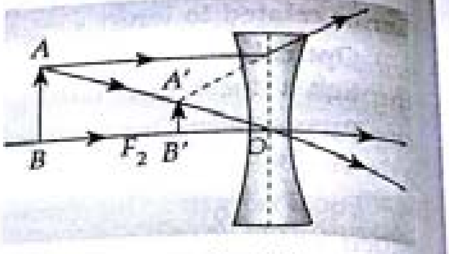
	Position of object	Position of image	Nature, Size, Position of image
(a)	At infinity (∞)	At F_2	real, very small and inverted
(b)	Left near $2F_1$	Between F_2 and $2F_2$	real, small and inverted
(c)	At $2F_1$	At $2F_2$	real, equal and inverted
(d)	Between $2F_1$ and F_1	Right from $2F_2$	real, large and inverted
(e)	At F_1	At infinity (∞)	real, very large and inverted
(f)	Between O and F_1	Towards objects	Virtual, erected and magnified



The image formation by concave lens : By concave lens often the image is formed towards the object side (left) between the focus and lens and it is virtually erected and small.

Object can be kept at various position and image can be obtained.

Relation among object distance, image distance and focal length of the lens.

$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$ is called lens formula and it is the required relation between the distance of object and image with focal length.

Here, f = focal distance, $+ve$ for convex lens and $-ve$ for concave lens.

u = object distance

v = image distance.

Relation among focal distance, index of refraction and radius of curvature.

(a) Thin lens formula : $\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

where μ = index of refraction of the lens.

f = focal length

R_1, R_2 are radii of curvature of two surfaces.

If the lens is a plano-convex then $R_2 = \infty$

Thus, by lens formula $\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{\infty}\right)$

$$= (\mu - 1)\left(\frac{1}{R_1} - 0\right) = \frac{\mu - 1}{R_1} \Rightarrow \frac{1}{f} = \frac{\mu - 1}{R_1}$$

(b) Thick lens formula : If t be the thickness of the lens then

$$\frac{1}{f} = (\mu - 1)\left\{\frac{1}{R_1} - \frac{1}{R_2} + \frac{(\mu - 1)t}{\mu R_1 R_2}\right\}$$

Equivalent focal length of two lenses :

(a) If two lenses are kept in contact then equivalent focal length of these two lenses is the sum of the focal lengths of the lenses.

Thus if F is the equivalent focal length of two lenses whose respective focal lengths are f_1 and f_2 then $\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2}$

(b) But if these two lenses are kept apart at d distance, then its equivalent focal length is given by

$$\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2} - \frac{d}{f_1 f_2}$$

Power of a lens : The inverse of the focal length of any lens is called *power of the lens*. If the focal length of a lens is in meter, then its inverse which is called power of the lens is expressed in *Dioptre*. Thus, SI unit of the power of the lens is dioptre. Since the focal lengths of convex and concave lenses are +*ve* and −*ve*. That's why convex lens has +*ve* power and concave lens has −*ve* power.

Equivalent power of the combination of lenses : As from the formula of equivalent focal length of two lenses when these two are in contact.

$$\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2} \Rightarrow P = P_1 + P_2$$

If first lens is concave, say $P_1 = -1.5$ (dioptre)

and second lens is convex, say $P_2 = f = +2.5$ (dioptre)

then $P = -1.5 + 2.5 = +1$ dioptre

Also, if d is the distance between two lenses, then $P = P_1 + P_2 - d\,P_1\,P_2$.

Variations in the power of lenses : Whenever a lens is kept inside a liquid its focal length and power both change. If a lens of refractive index μ is kept inside a liquid of refractive index μ' then here three cases arise;

(a) When $\mu > \mu'$: Here power of the lens decreases and thus focal length increases. The nature of the lens remains the same.

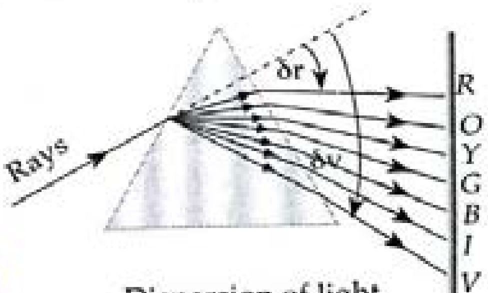
(b) When $\mu = \mu'$: Here focal length of the lens becomes infinite and thus power of the lens vanishes or becomes zero. Thus lens behaves like a plane parallel plate and inside the liquid lens doesn't look.

(c) When $\mu < \mu'$: Here power of the lens again decreases and thus focal length increases. Thus a convex lens acts like a concave lens and vice-versa.

An air bubble inside the water acts like a concave lens but as usual (without water) acts like a convex lens. A convex lens of glass when kept inside the carbon disulphide appears like a concave lens and vice-versa.

6. Dispersion of light

When a light ray incidents upon a prism, it gets refracted through it and bends towards the base of the prism and this ray splits into various colours. This group of component colours is called spectrum. Also the process of splitting of a white light is called *dispersion of light*. In all the colours of white light, violet ray (colour) deviates the most and red ray (colour) deviates the least. The white light has seven colours **VIBGYOR** (Violet, Indigo, Blue, Green, Yellow, Orange and Red).



Dispersion of light

Newton observed that different colours of white light deviate on different angles. The optical dispersion takes place because different colours of white light have different speeds for any transparent material. As well as the refractive indices of various colours of the light increase correspondingly their speeds decrease.

For example : The violet ray (colour) has the largest refractive index and the least speed in glass and red ray (colour) has the least refractive index and the largest speed. Other colours have their speeds between these two colours—violet and red.

Also the wavelength of violet colour is the least and that of the red colour is the largest. The wavelength of light is expressed in *Angstrom* (Å) and 1Å = 10^{-10}m.

Wavelength of important colours :

Colour	Wavelength (in Å)	Colour	Wavelength (in Å)
Violet	3969 Å	Yellow	5893 Å
Blue	4861 Å	Red	6563 Å

Rainbow : When the phenomena of refraction, reflection and total internal reflection take place coincidentally and in which a comprehensive optical dispersion also takes place then a rainbow is formed.

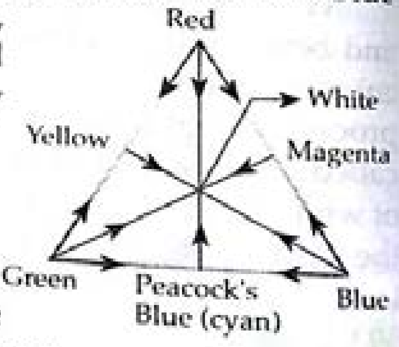
The rainbow is of two types—

(i) Primary rainbow : Whenever rainfall occurs then after its complete end some rain drops remain suspended in the sky and in the meantime if any light ray (from the sun) incidents on a particular drop in such a way that it reflects one time and refracts two times then primary rainbow is formed. In it red colour is located outwardly and violet colour is located inwardly. Inwardly located violet ray makes an angle of 40°.8 and outwardly located red ray makes an angle of 42°8' at the eye.

(ii) Secondary rainbow : As above if the light ray (from the sun) incidents on a particular drop in such a way that reflects two times and refracts two times then secondary rainbow is formed. In it violet colour is located outwardly and red colour is located inwardly. Outwardly located violet ray makes an angle of 54° 52' and inwardly located red ray makes an angle of 50° 8' at the eye.

The secondary rainbow is less distinctive and clear than the primary rainbow.

Primary, secondary and complementary colours : Red, Green and Blue colours are called *primary colours*, while Yellow, Magenta and Peacock Blue (cyan) colours are called *secondary colours*. These colours are prepared by mixing two primary colours as below :



Red + Blue → Magenta.
Green + Blue → Peacock Blue (Cyan)
Red + Green → Yellow

If two colours mutually meet to form a white light, then the colour is called complementary colour.

Example : Red + Peacock Blue (Cyan) → White.
Green + Magenta → White.
Yellow + Blue → White, Red + Peacock Blue (Cyan) → White.

Such type of colours cannot be achieved in our daily life because colours which we use are practically impure.

Colour TV utilises primary colour—red, green and blue.

Colour of Objects : The colour of any object is the reflected colour and all other colours are absorbed. The object which reflects all the incident colours looks white but if all the incident colours the are absorbed then the object appears black. The white colour of an object is the composite effect of all the colours.

Example : When a red rose is seen through a green glass then the rose appears black because red colour is not available for reflection and green colour is absorbed by it.

The colours effect on various type of objects

Name of objects	In white rays	In red rays	In green rays	In yellow rays	In blue rays
White paper	white	red	green	yellow	blue
Red paper	red	red	black	black	black
Green paper	green	black	green	black	black
Yellow paper	yellow	black	black	yellow	black
Blue paper	blue	black	black	black	blue

7. Interference of light waves

In general interference is the phenomenon of sustained cancellation or reinforcement of two waves when they meet under certain specific conditions. When the effect of one wave is constantly neutralised by the other, two waves are said to interfere destructively and when their effects are reinforced they are said to interfere constructively. Thus, we can say that when two waves of the same frequency travel in same direction and have a phase difference that remains constant with time, the resultant intensity of light is not distributed uniformly in space. The non-uniform distribution of light intensity due to superposition of two waves is called *interference.* At some points intensity is maximum and interference at these points is called *constructive interference.* At some other points intensity is minimum (possibly even zero) and interference at these points is called *destructive interference.* Usually when two light waves are made to interfere, we get alternate dark and bright bands of a regular or irregular shape. These are called *interference fringes.*

Interference is the most fundamental characteristic of a wave and there is no loss of energy in it, there is only redistribution of energy from maxima to minima. The phenomenon of interference was firstly demonstrated by Thomas Young in his experiment called *Young's double slit experiment.*

Examples related to interference

(i) The kerosene oil spread on the water surface seems to have a decent colour because of interference of the light.

(ii) The soap bubbles have a brilliant colour in the sunlight because of interference of the light.

Coherence : A wave which has a pure sine wave for an infinitely large period of time or for an infinitely extended space is said to be a *perfectly coherent wave.* In such a wave there is a definite relationship between the phase of the wave at a given time and at a certain time or distance later at a given point same condition is again satisfied.

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No actual light source however emits a perfectly coherent wave. Light waves which are pure sine waves only for a limited period of time or in a limited space are partially coherent waves.

Thus there are two different criteria of coherence–criteria of time and criteria of space. This gives rise to the phenomena of *temporal coherence* and *spatial coherence*.

8. Diffraction of light

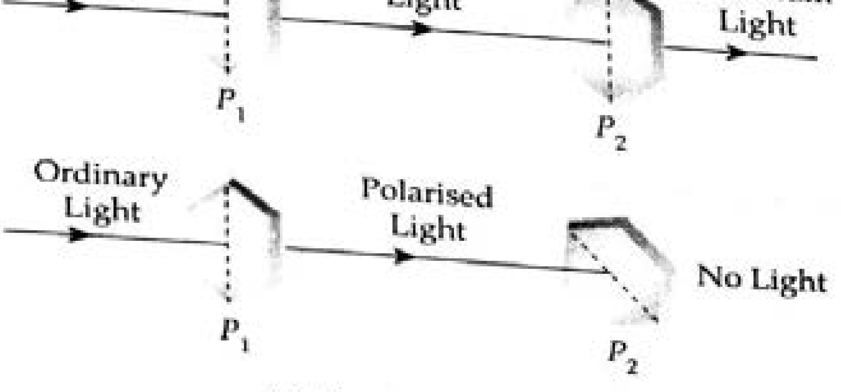
If an opaque obstacle (aperture) is kept between a source of light and a screen, a sufficiently distinct shadow (or an illuminated region) is obtained on the screen. This shows that light which travels the obstacle (aperture) is small (comparable to the wavelength of the light), there is a departure from straight line propagation and so the light bends round the corners of the obstacle (aperture) and enters in the geometrical shadow. This bending of the light is called *diffraction*. Consequently, the edges of the shadow (or illuminated region) are not sharp, but the intensity is distributed in a certain way depending upon the nature of the obstacle (aperture). Thus, if the size of the obstacle is in the order of the wavelength of light, then diffraction will be appeared which is clear and distintive. The phenomenon of diffraction confirms the wave character of the light. Sound wave has longer wavelength, that's why acoustical diffraction takes place clearly in which sound wave bends from obstacle and we listen. While the wavelength of light wave is shorter than common barrier (obstacle) we use in our daily life, that's why the phenomenon of optical diffraction is rarely observed.

There are two types of optical diffractions—

(a) Fresnel's diffraction : In Fresnel's class of diffraction, the source of light or screen on which diffraction pattern is observed, are usually at finite distances from the diffraction obstacle (aperture). In this case no lenses are used and the wavefront (wave shape) is either spherical or cylindrical.

(b) Fraunhofer diffraction : In Fraunhofer's class of diffraction, the source of light and the screen are effectively at infinite distances from the diffracting obstacle (aperture). This is achieved by keeping the source and screen in the focal planes of two lenses. Here the incident wavefront (wave shape) is plane.

9. Polarisation of light waves

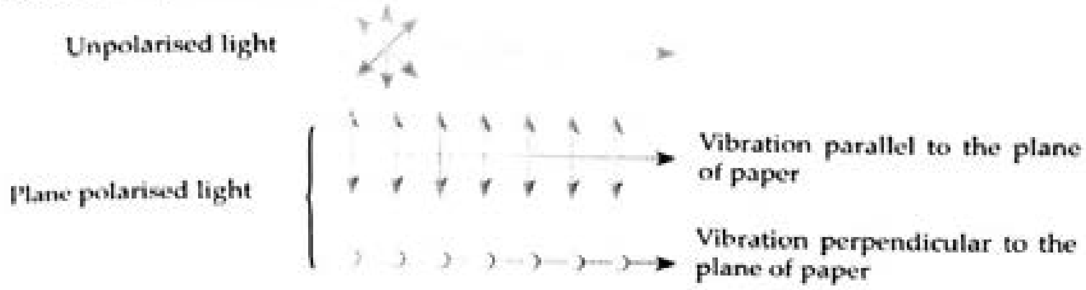


P_1, P_2 → tourmaline crystals

When an ordinary light incidents normally upon a pair of parallel tourmaline crystal plates P_1 and P_2 as shown in the figure which have been cut parallel to their crystallographic axis, the emergent light shows a variation in intensity as P_2 is rotated. The intensity is maximum when the axis of P_2 is parallel to that of P_1, and minimum when it is at right angles. This shows that the light emerging from P_1 is not symmetrical about the direction of propagation of light, but its vibrations are confined only to a single line in a plane perpendicular to the direction of propagation. Such light is called *plane-polarised* or *linearly-polarised* light.

According to the electromagnetic theory of light, a light wave consists of electric and magnetic vectors vibrating in mutually perpendicular planes, both being perpendicular to the direction of propagation of light. The electric vector acts like a light vector. Hence, the plane-polarised light is a light in which the light vector vibrates along a fixed straight line in a plane perpendicular to the direction of propagation.

Symbolical representation


Unpolarised light
Plane polarised light
Vibration parallel to the plane of paper
Vibration perpendicular to the plane of paper

As in an unpolarised beam of light all directions of vibration at right angles to that of propagation of light are possible, hence it is represented by a star.

In a plane-polarised beam of light the vibrations are along a single straight line. If the vibrations are parallel to the plane of the paper, they are represented by the arrows. If they are along a straight line perpendicular to the plane of paper, they are represented by dots.

Light waves are transverse : In tourmaline experiment, the variation in intensity of the emergent light on rotation of P_2 (First section of the polarisation) shows that light waves are transverse. But if the waves were longitudinal i.e. having vibration along the direction of propagation of light, they will have passed through P_2 in all positions of it.

Thus, polarisation of light takes place with transverse waves only and doesn't occur with longitudinal waves. That's why sound (longitudinal) wave doesn't exhibit the phenomenon of polarisation.

Doubly-Refracting crystals : There are certain crystals which split a ray of light incident upon them into two refracted rays. Such crystals are called *doubly-refracting crystals.* These are of two types : uniaxial and biaxial. In uniaxial crystals there is one direction called *optic axis* along which the two refracted rays travel with the same velocity. The examples of such crystals are calcite, tourmaline and quartz. In biaxial crystals there are two optic axes. The examples of biaxial crystals are topaz and arogonite.

Double refraction : When a ray of unpolarised light incidents on a calcite (or quartz) crystal, it splits up into two refracted rays. The phenomenon is called *double refraction.*

One of these two refracted rays is found to obey the laws of refractio i.e. it always lies in the plane of incidence and its speed in the crystal i same in all directions. This ray is called an *ordinary ray* (O-ray). The othe refracted ray doesn't obey the laws of refraction. It travels in the crystal wi different speeds in different directions. Hence it is called an extraordinar ray (E-ray). Along the optic axis, however, O-ray and E-ray both have th same velocity and hence the same refractive index. An ordinary ray (O-ray) and an extraordinary ray (E-ray) obtained through the double refraction ar plane-polarised.

Nicol's prism : It is an optical device made from a calcite crystal which is used in producing and analyzing the plane-polarised light.

Dichroism : Some doubly-refracting crystals have the property of absorbing strongly one of the two refracting rays, while allowing the other to emerge with a little loss. This selected absorption by the crystal is known as *dichroism*. The best example of such a crystal is tourmaline.

When a ray of unpolarised light is sent through a 1 mm thick, tourmaline plate then it splits up into plane-polarised light in which O-ray and E-ray vibrate in mutually perpendicular planes. O-ray is completely absorbed while E-ray is totally transmitted. Thus, the light emerging through the plate is plane-polarised. This is the basic principle of the commercial polarising devices called *polaroids*.

Polaroid : It is a large-sized polarising film mounted between two glass plates, and is used to obtain plane-polarized light for the commercial purposes. The film consists of a thin sheet of nitro-cellulose packed with ultra microscopic crystals of the organic compound iodosulphate quinine (also called herapathite) with their optic axes all parallel. These crystals are highly dichroic, absorbing one of doubly-refracted beams completely. Hence when a beam of unpolarised light passes through the polaroid film, the emerging light is plane-polarised.

Recently large-sized polaroids have been made by stretching a film of polyvinyl alcohol. The stretching orients the complex molecules with their long axes in the direction of stress and makes them doubly-refracting. Then the film is impregnated with iodine which makes it dichroic. Such polaroids are called *H*-polaroids. If instead of iodine impregnation, the stretched film is heated with a dehydrating agent, then it slightly darken and becomes strongly dichroic. It is called *K*-polaroid.

Uses of polaroids

(i) Polaroids are used in the laboratory to produce and analyse a plane-polarised light. These are cheaper than Nicols.

(ii) K-polaroids are used in head-lights and wind-screens of cars to cut off the dazzling light of a car approaching from the opposite side. They are fitted in the head-light and wind-screen of the car with their vibration-planes parallel to each other but inclined at 45° to the vertical. When two cars approach each other from the opposite sides then through the vibration-plane of polaroids light is sent out to each other and hence light coming from the head light of one car is completely cut off by the wind-screen of the another car and thus the driver is able to see the other car by the light sent out from his (or her) own car.

(iii) Polaroids are used to control the intensity of light in entering trains and aeroplanes. A polaroid is fixed outside the window, while the other is fitted inside it which can be rotated and the intensity of light can be adjusted by rotating the inner polaroid.

(iv) Polaroid glasses are used in viewing three-dimensional pictures.

(v) The polaroids are today frequently used in sun-glasses to cut off the glare of light reflected from the horizontal surfaces such as moist roads, cover glasses of the paintings, polished table, pavements etc.

Plane, Circularly and Elliptically polarised light : According to Maxwell's electromagnetic theory, a light wave consists of electric and magnetic fields (vectors) vibrating in mutually perpendicular planes, both being perpendicular to the direction of propagation of light. The electric vector is responsible for the optical effect of the wave and which is also called *light vector.* In unpolarised light, light vector takes all the possible directions of vibration in a plane perpendicular to the directions of propagation. If however, light vector vibrates along a fixed straight line in the plane, the light is said to be *plane-polarised or linearly-polarised.*

When two plane-polarised waves are superimposed, then under certain conditions the resultant light vector rotates with a constant magnitude in a plane perpendicular to the direction of propagation. The tip of the vector traces a circle and the light is said to be *circularly-polarised.* If, although the magnitude of the resultant light vector varies periodically during its rotation, the tip of the vector traces an ellipse, the light is said to be *elliptically-polarised.* Thus, there are usually three types of polarised light which exist in nature.

10. Scattering of light

When light waves fall on extremely small bodies (particles) such as dust particles, very small suspended water droplets, suspended particles in colloidal solution etc then these are thrown out in all directions. This phenomenon of light is known as *scattering.* Here bodies are small in the sense of their sizes and are smaller than the sizes (wavelengths) of the incident waves. Thus, the strength of scattering depends upon the wavelength of the light beside the size of the bodies (particles) which cause scattering. If these particles are smaller than the wavelength of the incident light, then the scattering is proportional to $\frac{1}{\lambda^4}$. This is called *Rayleigh's law* of *scattering.* Thus, red light is scattered least and violet is scattered most. That's why red signals are used to indicate dangers. Such a signal appears to be visible at a larger distances without an appreciable loss due to scattering.

Incidents of the scattering of light in our daily life—

(i) Due to the scattering of light sky appears blue : When we look at the sky it is scattered light from the atmosphere that enters the eyes. Among the shorter wavelength the colour blue is present in larger proportion in the light. Light of short wavelengths are strongly scattered by the air molecules and the suspended water droplets and it explains the blue colour appearance of the sky.

(ii) At sunset and sunrise sun appears red : At such occasion the sunlight has to travel a large distance through the atmosphere. The blue and neighbouring colours are scattered away in the path and the light reaching the observer is predominantly red. Thus, at sunset and sunrise sun appears red and it occurs due to the scattering of light.

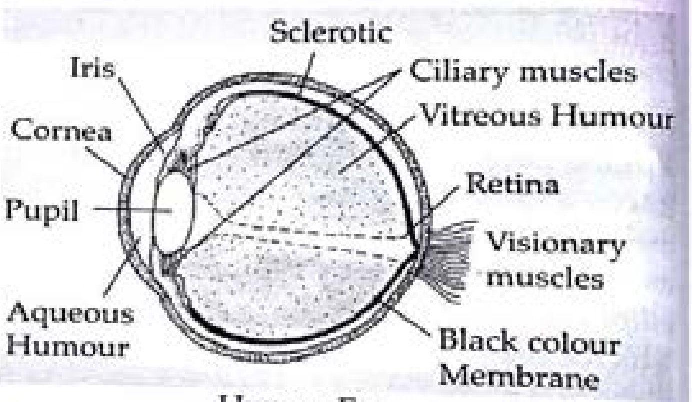
(iii) If there were no atmosphere of the earth, then the sky would appear black and stars would be seen during the day.

(iv) On a humid day before rains, the sky appears light blue, while on a clear day it appears deep blue. The change in the quality of colour of the sky results from the fact that the water droplets and the dust particles may have a size larger than the wavelength of light. Rayleigh's law of scattering doesn't apply in this case and colours other than blue may be scattered in larger proportion.

(v) The seas also appear blue due to the scattering of light.

11. Human eye

The human eye is like a camera with the help of which we see the objects. Human eye is externally very hard and it is covered with a opaque white membrane which is called *sclerotic*. The front part of sclerotic is concave which is called *cornea*. During eye donation this part (cornea) is donated.



Human Eye

A light ray enters the eye through cornea. Behind the cornea a colour opaque membrane is located which is called Iris. In the middle of the *Iris* there is a sharp hole, which is called *pupil*. Iris controls the amount of light which enters the eye. If more light comes into it, then automatically iris compresses itself. Also in dark or insufficient light it (iris) automatically expands. Behind the pupil the eye lens is located. The eye lens is made from many layers whose index of refraction increases from outside to inside and its mean index of refraction is approximately 1.44. The eye lens is confined within the musclular region and it is capable of adjusting its focal length. That's why human eye has a variable nature of focal length. Between cornea and eye lens a saline transparent fluid is filled up which is called *aqueous humour*, and its index of refraction is 1.336. Behind the eye lens another transparent fluid is also found which is called *vitreous humour* and whose index of refraction is also 1.336. Behind sclerotic there is a black coloured membrane which is called *choroid*. It absorbs the light and stops the process of internal reflection. Inside this membrane and in the innermost part of the eye there is a transparent membrane which is called *retina*. The retina is basically a film of optical nerves and these nerves produce the sensation of the image formed in the mind (brain). Thus, shape, size and colour of the object's image is observed by the human eye. When a light ray incidents on an object, then by reflection it passes through the cornea and aqueous humour reaches to the retina. At retina (used as screen for the glass lens) a real and inverted image of the object is formed and this message is sent to the human brain by the visionary (optic) nerves and the brain realises the real erected image. There is no effect of light is found the place (point) where optic nerves by making the hole in the retina goes upto brain. This place is called *blind spot.* There is a mid-point in the retina which is of yellow colour. Here the obtained image is very sharp and distinctive. It is called *yellow spot.*

Power of accommodation of eye : To see any object distinctly (clearly) it is necessary that the light ray reflected from object be totally confined on the retina. In usual condition the light rays coming from far flung object are assumed to be confined on the retina by which the muscles of the eye is not stretched as normally and the object looks. At this position the eye lens has the maximum focal length. But if the eye looks at any nearer object, then eye muscles start to shrink and reduce the radii of curvature of the lens surfaces. Here the focal length of the eye lens is reduced and again image starts to form on the retina. This adjustment of the focal length of the eye is called Power of accommodation of the eye. As we try to look at the nearest object more and more power of accommodation of the eye is required and it has also a limit. If any object is kept very close to the eye it doesn't look distinct. Thus the maximum accommodation power of eye is applied to the nearest object which looks sharp and distinct. This distance of distinct vision is called the least distance of distinct vision and for a normal human eye it is 25 cm. But inversely the eye without applying the power of accommodation can see distinctly any object located at far point and for a normal human eye it is infinity (∞).

Colour vision : There are two types of cells found in the retina of the eye which are optically sensitive. These are called cones and *rods.* Cone shaped cells react according to the consistency of the colours by which we realise about the colours. Rod shaped cells react according to the consistency of the intensity of light. This is very sensitive for the dim light. That's why we also speculate (guess) about the object in the dark. When light is of shining (dazzling) type then rods cells stop to act and cones cells become active. A normal human eye's retina has three types of cones cells—

(i) **First type**–Sensitive to the light of shorter wavelength (blue colour)

(ii) **Second type**–Sensitive to the light of middle range wavelength (green colour)

(iii) **Third type**–Sensitive to the light of longer wavelength (red colour)

Chromatic adaptation : If a piece of glazed (shined) colour paper is taken and half part of it is covered, then on looking up to approximately 30 seconds at the rest of the piece and if the covered part is now made open then on looking at the entire piece the covered part appears more glazed. This optical incident is called chromatic adaptation.

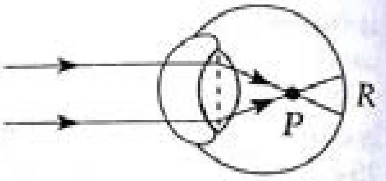
Successive contrast : If we look at a coloured image up to approximately 30 seconds and a white surface is seen then a post-image appears, whose shape and size is equal to that of the real image, but its colour is different. If the real image is red then its post-image is green and vice-versa. If the real image is blue then its post-image in yellow and vice-versa and for the white real image its post-image is black and vice-versa. Such optical incident in technical form is called successive constrast.

Chromatic Induction or Simultaneous contrast : The distinct vision of any colour depends on the all around colours. If we look at a particular colour in various layers of the surfaces where various colours are to be confined it looks different. If any colour is seen in the background of a sharp colour, then this colour seems to be light, but in the domain (background) of light colour this colour seems to be sharp. This relative distinction in the colour is called chromatic induction or simultaneous contrast.

Phantom colour : Sometimes we look at colours in the region of black and white. These colours are called phantom colours. They can be observed in a black and white TV specially when pictures pass very quickly.

Eye defects (Defects of vision) : For a normal human eye, the least distance of distinct vision is 25 cm. Normal human eye can cast the image of an object on the retina of the eye between the least distance of distinct vision and infinity (∞). But due to late or old age and also due to some other reasons the power of the eye lens is damaged or diminished, and it is called eye defects. There are various types of eye defects—

(i) Myopia or short sightedness : The person suffering from myopia cannot see the distant objects but easily see the near most objects.



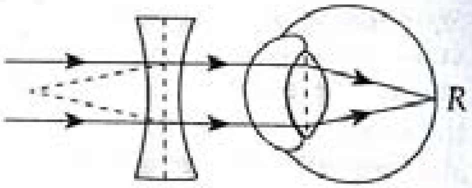
Myopia

Causes :

(a) The sphericity of the eye lens is increased.

(b) The focal length of the lens decreases.

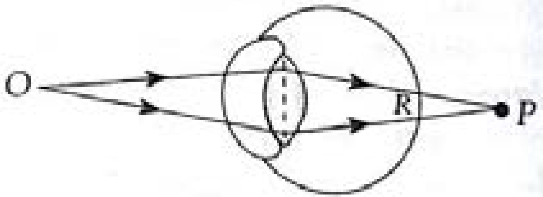
(c) Power of the eye lens increases, thus here the image doesn't form on the retina but in the defective eye it forms in the front of retina.



Remedy of Myopia

Remedial measure : The myopia affacted person uses concave lens of suitable focal length so that the image starts to form on the retina.

(ii) Hypermetropia or Long-sightedness : The person suffering from hypermetropia cannot see the near most objects but can see the objects located at remote distances.



Hypermetropia

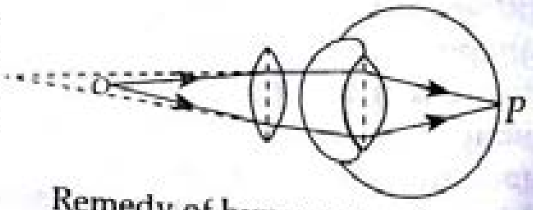
Causes :

(a) The sphericity of the eye lens is decreased.

(b) The focal length of the lens increases.

(c) Power of the eye lens decreases, thus here the image doesn't form on the retina but forms just behind it.

Remedial measures : The hypermetropia-affected person uses convex lens of suitable focal length so that now the image starts to form on the retina.



Remedy of hypermetropia

(iii) Presbyopia : In old age, the power of accommodation of the eye is diminished (ended) due to which person can see neither the near object nor the far flung object.

Remedial measures : The presbyopia affected person uses *bifocal lens* of suitable focal length.

(iv) Astigmatism : The person suffering from astigmatism sees clearly horizontally but not being capable to look vertically. The person affected by it uses *cylindrical lens* of suitable wavelength.

(v) Colour Blindness : Every human eye by nature is not able to see every colour distinctly and this defect of vision is called colour blindness. Colour blindness is of many types and it occurs at various levels. The colour blindness depends on various defects of the cylindrical (conical) cells of the retina. The colour blindness is basically a hereditary disease which is not curable. The person suffering of colour blindness cannot distinguish the red and green colours distinctly.

(vi) Persistence of vision : The image of an object persists on the retina of the eye upto 1 / 10 second. If the object is then removed from the eye, the object viability persists upto 1 / 10 second. This special characteristic of vision is called persistence of vision. Cinema works on this principle. Due to persistence of vision various celestial phenomena occur in the sky. The blades of fast moving electric fan also appears indistinctive due to the same reason.

12. Optical Instruments

(i) Camera : The camera is an optical device with which photographs of various objects are taken on the photographic plate or film and by developing the reel permanent photos are prepared.

Ordinarily a camera is of two types—

(a) Box camera (b) Folding camera

Important parts of the camera

Light insulated box : This is made of wood or metal whose length is fixed in the box camera. But in folding camera this box is made of leather whose length is not fixed. This box is fully enclosed from every side so that no external light ray can enter inside to it. The inner part of the walls are black polished due to which light ray doesn't reflect.

Lens : In front of the light insulated box a convex lens is enclosed which is called objective. In good quality cameras the objective is made from the composition of various lenses. Due to it aberration in the image doesn't appear.

Diaphragm : Just in front of the objective a round metallic screen is enclosed in which a hole is made through which the light in the camera enters which is called diaphragm. The size of the hole is adjustable which can be increased or decreased according to requirement.

Shutter : Behind the lens an autocut plate is attached which is called shutter. Whenever a shutter is enclosed light doesn't enter inside the camera. During taking photographs it is opened and light is focused on the film or photographic plate upto a definite time interval like 1 / 10, 1 / 50, 1 / 100, ...

etc and the times are called time of exposure. The time of exposure is decided by various parameters like value of aperture, speed of the film, intensity of the light etc.

Ground glass screen : It is a plate of grounded (or rubbed) glass which is enclosed in the rear part of the camera. The distance of the lens from it is adjusted in such a way that the image of the object is taken sharply and distinctly. After adjusting the distance the photographic plate or the film is attached.

Terms related to camera

Aperture : The effective diameter of the lens is called aperture.

Relative aperture : It is the ratio of effective diameter and focal length of the lens.

$$\text{Thus; relative aperture} = \frac{\text{Effective diameter of the lens}}{\text{Focal length of the lens}}$$

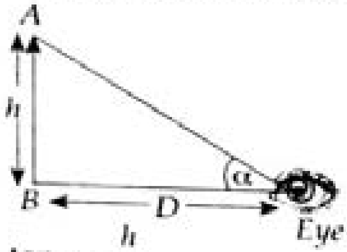
Focal ratio : The reciprocal of the relative aperture is called focal ratio.

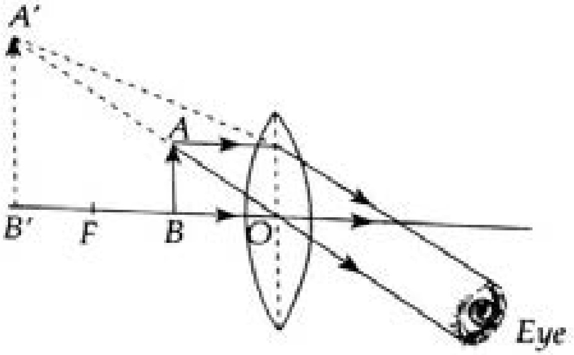
$$\text{Thus focal ratio} = \frac{\text{focal length of the lens}}{\text{effective diameter of the lens}}$$

***f* - number :** The numerical value of the focal ratio is called *f* - number.

$$\text{Thus; } f\text{ - number} = \frac{\text{focal distance}}{\text{effective diameter}} = \frac{f}{d}$$

(ii) Simple Microscope (Magnifying Glass) :





$\tan \alpha = \frac{h}{D}$

h = length of the object AB

D = least distance of distinct vision

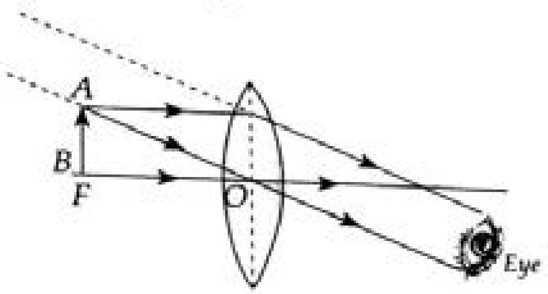
The simple microscope is an optical instrument in which a convex lens of small focal length is taken and the body (object) whose magnified image is to be obtained is kept between the optical centre (O) and the focus (F) of the lens. The image obtained through the simple microscope is virtual, erected and magnified. Also as the angle made by the image at the eye is greater than the angle made by the object and thus it acts as magnifying glass. A more curved convex lens has a more magnification, due to shorter focal length of the lens the image of the object is formed nearer and consequently the angle made on the eye is large. Thus, the object appears more magnified.

Magnifying Power : The magnifying power of any lens is defined as the ratio of angle made by the image (β) at the eye to the angle made by objects (α) at the eye at the least distance of distinct vision.

$$\text{Thus; magnifying power } (m) = \frac{\beta}{\alpha}$$

For a simple microscope, magnifying power (m) = $1 + \frac{D}{f}$

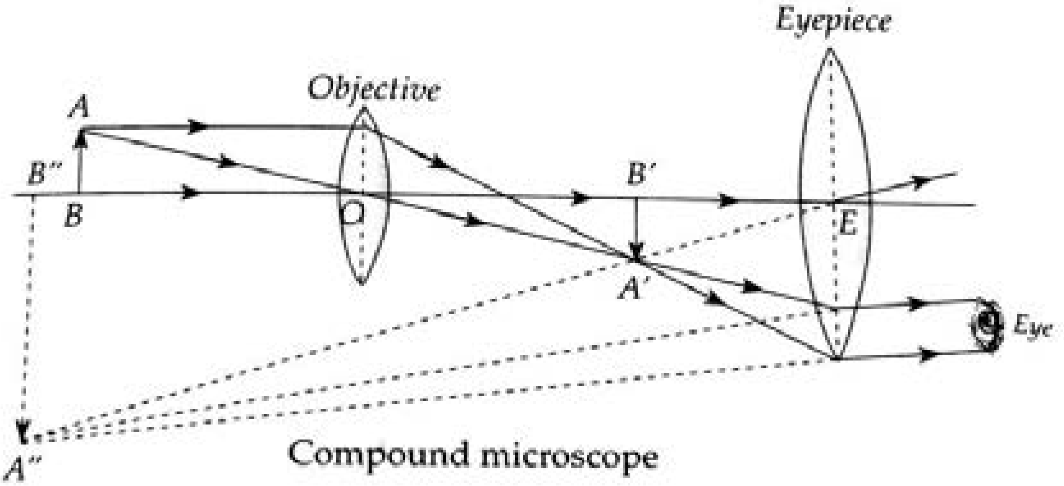
where, D = least distance of distinct vision.
= 25 cm.
f = focal length of the simple microscope.



Virtual Image at infinity : If in a simple microscope the object is kept at the focus (F) of the lens then a virtual image is formed at infinity.

Here, the magnifying power of the simple microscope $(m) = \frac{D}{f}$.

(iii) Compound Microscope : It is an optical instrument which magnifies the image of the object substantially and the magnifying power of the microscope is obtained from two parts (components) called compound microscope. The compound microscope consists of two coaxial convex lenses, one is called objective near to which object is located and the other is called eyepiece near to which the eye is located.



Compound microscope

The aperture and focal length of the objective is smaller than that of the eyepiece in the compound microscope. The focal lengths of the objective is smaller than the eyepiece. Both objective and eyepiece are coaxially adjusted in a tube (pipe) in which the image formed by the objective acts as an object for the eyepiece and ultimately a magnified image is formed at the least distance of distinct vision.

Magnifying power: The magnifying power of the compound microscope

$$= m_o \times m_e = \left(\frac{v_o}{f_o} - 1\right)\left(1 + \frac{D}{f_e}\right) = \frac{v_o}{u_o}\left(1 + \frac{D}{f_e}\right)$$

If L is the distance between the objective and eyepiece

then magnifying power (m) =

$$\left(\frac{L - \frac{Df_e}{D + f_e}}{f_o} - 1\right)\left(1 + \frac{D}{f_e}\right) = \frac{D(L - f_o - f_e) + f_e(L - f_e)}{f_e f_o}$$

where m_o = magnifying power of objective.
m_e = magnifying power of eyepiece.
u_o = distance of the object from objective.
v_o = distance of the image from objective.
D = least distance of distinct vision = 25 cm.
f_o = focal length of objective.
f_e = focal length of eyepiece.

(iv) Telescope : An optical instrument through which the sharp and distinct images of the celestial bodies or smaller bodies (objects) located at far flung distances (remotely located) are easily seen and measured.

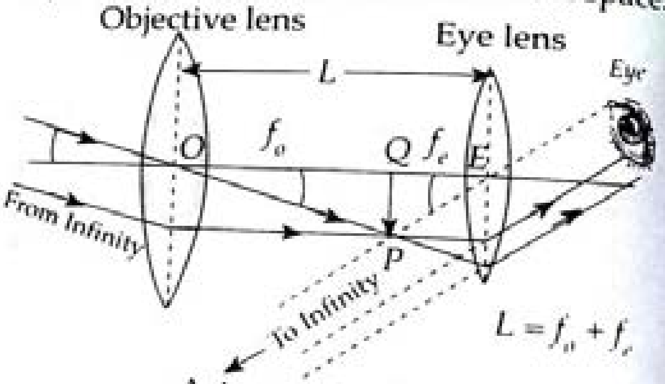
Generally telescopes are of two types—

(A) Refracting Telescope (B) Reflecting Telescope

In this book we have studied only about the refracting telescopes and the study of reflecting telescopes is beyond the extent of this book which has no significant relevancy in the book of General Science.

(A) Refracting Telescope : It is of three types :

(a) Astronomical Telescope : The astronomical telescope was firstly constructed by Denmark's astrologer Kepler in 1911. With the help of this telescope distant astronomical objects (celestial bodies) are seen in the space. This telescope consists of two convex lenses, one of which is called objective whose aperture and focal length are large and it is kept in a long flat pipe, while another is called eyepiece whose aperture and focal length are small compared to the objective. The eyepiece is kept in another small thin pipe and these two pipes are interconnected to each other. Both objective and eyepiece are kept coaxially inside in the pipe.



Astronomical Telescope

The accommodation in astronomical telescope is done by two methods :

(i) Accommodation for infinity : The final image in this mode of accommodation is formed at infinity in which the image is too much magnified. Such accommodation is called focusing at infinity.

(ii) Accommodation for the least distance of distinct vision : The final image in this accommodation is formed at the least distance of distinct vision (25 cm) and accommodation is called focusing for normal vision. Here image is inverted, magnified and distinctive.

Magnifying power of an astronomical telescope :

(i) Magnifying power when image is formed at the least distance of distinct vision. The magnifying power $(M) = \frac{f_o}{f_e}\left(1 + \frac{f_e}{D}\right)$

$$\therefore \Rightarrow \quad M = \frac{f_o}{f_e}\left(1 + \frac{f_e}{D}\right)$$

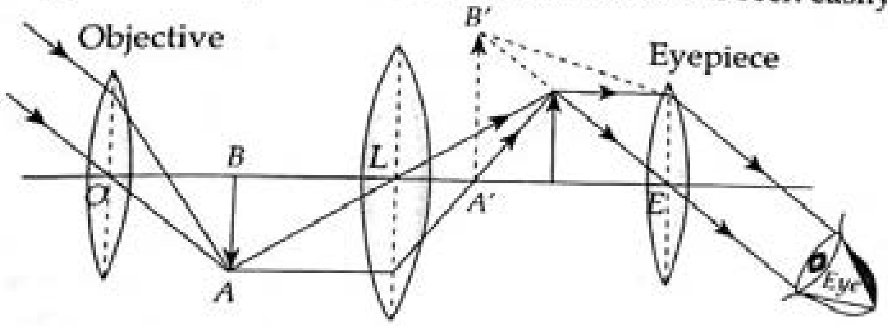
(ii) Magnifying power when image is formed at infinity $(M) = \frac{f_o}{f_e}$

(iii) If L is the length of the telescope then $L = f_o + f_e$ when image is formed at infinity.

(iv) If the image is forming at the least distance of distinct vision then the length of the telescope $= f_o + u = f_o + \frac{Df_e}{f_e + D}$

where f_o = focal length of the objective.
f_e = focal length of the eyepiece.
u = distance of the object.
D = least distance of distinct vision.
M = magnifying power.

(b) Terresterial Telescope : As the final image formed is inverted in the astronomical telescope. That's why this telescope is not suitable to see the objects located on the earth. Thus, if an arrangement is to be made to form an erect image, then this telescope is called terrestrial telescope. Now by this telescope distant object of the earth's surface can be seen easily.



Terresterial Telescope

In terrestrial telescope image formed is erect and virtual. Here accommodation is also done by two methods, one at ∞ and another at the least distance of distinct vision. In this telescope there are three coaxial convex lenses in which a convex lens of larger focal length is kept between objective and eyepiece through which a virtual image is obtained in the erect form.

Magnifying power

(i) If image is formed at infinity, then $(M) = \frac{f_o}{f_e}$,

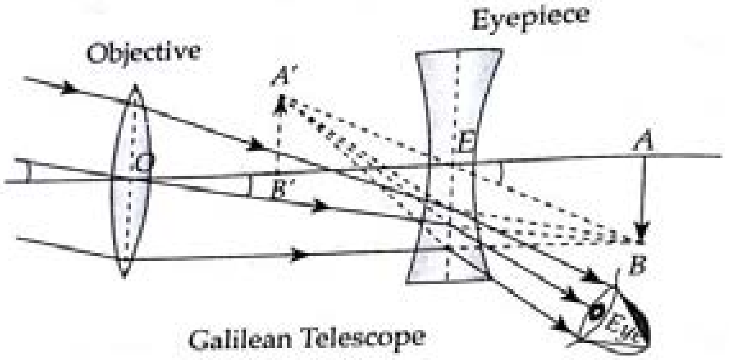
and the length of the telescope $= f_o + 4f + f_e$.

(ii) If image is formed at the least distance of distinct vision, then

$(M) = \frac{f_o}{f_e}\left(1 + \frac{f_e}{D}\right)$; length of the telescope $= f_o + 4f + \frac{Df_e}{D + f_e}$

where; f_o = focal length of objective.
f_e = focal length of eyepiece.
f = focal length of the middle lens.
D = least distance of distinct vision.
M = magnifying power (angular magnification).

(c) Galilean Telescope : This telescope was constructed in about 1609 AD by Galileo himself. In this telescope the objective is a convex lens of larger focal length and larger aperture, while eyepiece is a concave lens of larger focal length and smaller aperture. The arrangement in this telescope is also done by two methods. Here the image formed is always erect with respect to object.



Galilean Telescope

Magnifying power (*M*) :

(i) When image is formed at infinity.

$$M = \frac{f_o}{f_e}\text{; Length of the telescope} = f_o - f_e.$$

(ii) When image forms at the least distance of distinct vision.

$$M = \frac{f_o}{f_e}\left(1 + \frac{f_e}{D}\right)\text{;}\quad \text{Length of the telescope} = f_o - u = f_o - 1 + \frac{f_e D}{D - f_e}$$

Miscellaneous

Optical path : When a ray of light travels a distance d in a medium of refractive index μ, the product μd is called *optical path in* the medium. It represents the distance in air or more strictly in vacuum in which the light travels in the same time in which it travels the distance d in the medium.

Thus optical path = velocity of light in air × travelling time.

Thus, optical path ∝ travelling time.

Fermat's principle : A ray of light travelling from one point to another by any number of reflections and refractions follows a path for which compared with all other neighbouring paths, the time taken is either minimum or maximum or stationary. This is called *Fermate's principle of stationary* time or *Fermate's principle of extremum path.*

Cardinal points of a coaxial optical system : A coaxial optical system usually consists of a number of lenses placed apart and having a common principal axis. The position and size of the image of an object formed by such a system can be determined by considering refraction at each lens separately.

Gauss showed that if in an optical system the positions of certain specific points is known, the system may be treated as a single unit. The position and size of the image of an object may then directly be obtained by the same relations as used for thin lenses or single surface whatever complicated system may be. These points are called cardinal points or Gauss points of the optical system.

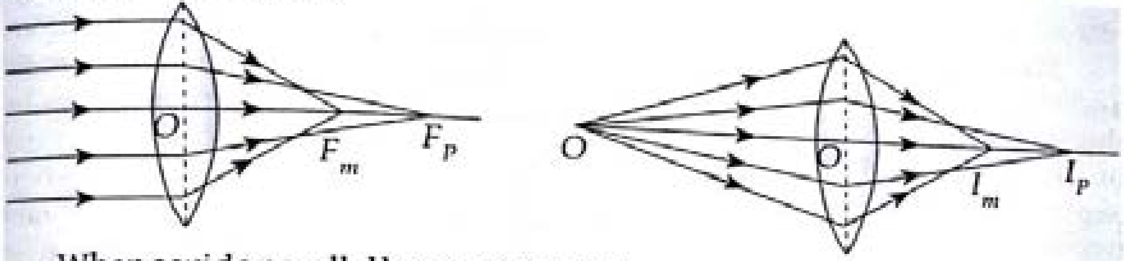
There are six cardinal points of an optical system; two focal points, two principal points and two nodal points.

Eyepiece : An eyepiece is a specially designed magnifier which gives a more perfect image than that obtained by a single lens of equal focal length. It is used in telescope and microscope to magnify the image formed by their respective objectives.

Chromatic Aberration : The image of a white object formed by a lens is usually coloured and blurred. This defect of the image is called *chromatic aberration*. It arises because the refractive index of the lens material varies with the colour (wave length) of the light.

Achromatism of lenses : When two or more lenses are combined together in such a way that the combination is free from chromatic aberration, then such a combination is called achromatic combination of the lenses or achromatism of lenses.

Spherical Aberration



When a wide parallel beam of light falls upon a convex lens in a direction parallel to the principal axis, it doesn't come to a single point focus. The paraxial rays (i.e. the rays lying close to the axis) after refraction through the lens come to a focus F_p, while marginal rays (i.e. the rays lying far from the axis) come to a focus F_m which is nearer the lens than F_p. Similarly when a point object O is placed on the axis of the lens, the paraxial rays come to focus at I_p, while the marginal rays come to a focus at I_m nearer the lens. The intermediate rays are brought to focus between I_m and I_p. This failure of the lens to form a point-image of an axial point-object is called *spherical aberration.*

V. Electricity & Magnetism

Section - A Electrostatics

A famous Greek philospher Thales in about 600 BC observed that when a glass rod was rubbed with a cat's skin, then the small paper pieces, corks etc were attracted by the glass rod and cat's skin. This implies that glass rod and cat's skin both are electrified or charged. Thales is assumed to be the founder of Modern electric era. Later, in 16th century the contemporary of Galileo Dr. Gilbert proved that like glass rod and cat's skin there are so many pairs which undergo for the process of electrification. The hard rubber (ebonite) and fur, ordinary glass and silk etc. can be electrified on rubbing and the characteristic of attraction of the small pieces of paper, corks, etc. become inherent. This is called frictional electricity or static electricity. Thus, electrostics is that branch of physics in which we study about the electrification of the bodies and in which charges remain static.

Kinds of charges : When an electric charge is produced by rubbing, then both rubbed bodies are electrified and both have same charges but of opposite nature. Thus, one has +ve charge and other has –ve charge. This concept of +ve and –ve charges was first given by Benjamin Franklin. Thus, in frictional electricity both nature of charges appear at a time in equal magnitude.

Here, we arrange a table in which every predecessor has a +ve charge and every successor has a *–ve* charge.

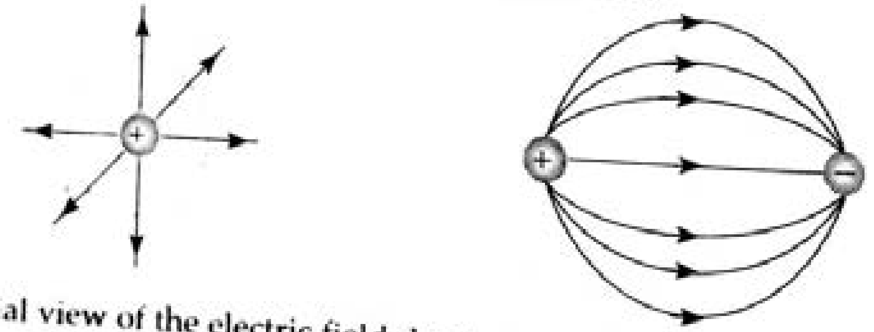
1. Fur
2. Flannel
3. Leather
4. Wax
5. Glass
6. Paper
7. Silk
8. Human body
9. Wood
10. Metal
11. Rubber
12. Resin
13. Amber
14. Sulphur
15. Ebonite
16. Gata-Parcha

It is also observed that like charges repel each other, while unlike charges attract each other.

Modern concept or principle of electricity : There were various opinions and views of scientists to explain frictional electricity but modern electronic theory had been comprehensively accepted. The outstanding contributions of Thomson, Rutherford, Millikan, Niels Bohr etc. are important in the explanation of modern electronic theory. According to this theory, when two bodies are rubbed then the electrons of the outermost orbit of the atoms of one body transfer to the atoms of the another body and thus, the first body has lesser number of electrons than the second body. Thereby, the first body becomes positively charged and the second body becomes negatively charged. This is the latest concept of electrification.

Electric field : If an isolated charge is kept anywhere then the region or space around it upto which if any other charged particle is brought then experiences a force. This region or space is called electric field. Theoretically (or ideally) this space is assumed to be infinite.

Electric lines of force : An electric field is sometimes visualised by drawing a set of lines, which are such that their direction of any point (i.e. the direction of the tangent) is the same as that of the electric field at that point, then such lines are called electric lines of force.



A pictorial view of the electric field due to a positive point charge and the pair of two equal and opposite (+ve and -ve) charges have been shown in the above figure.

These lines of force of an electric field are open and closed. They originate normally from the positively charged particle and terminate on the negatively charged particle Owing to the single valued property of the direction of the intensity of the electric field point of view two lines of force never intersect each other. Also if the electric field is stronger then there is a greater concentration of the lines of force but for a weaker (feable) field the electric lines of force are less concentrated.

Conductor : The body in which electric charge carriers (free electrons) are found to be mobile and due to which an electric current is generated then this type of body is called good conductor or conductor.

All metallic bodies, acids, human body etc. are good conductor of electricity. The best conductors are metallic bodies like— silver, copper, iron etc. Silver and copper are the two well known metals which have the best electrical conductivity. In all metallic bodies only free electrons are charge carriers due to which electric current generates.

Bad conductor and Insulator : The body which does not have mobile charge carriers are called bad conductor. Sometimes in a bad conductor also immobile charge carriers are activated to become free in a zig-zag way but not regularly like in wet rod of wood, thus it acts like a good conductor. But if the charge carriers are not able to make themself free then bad conductor is called insulator.

Wood, rubber, mica etc. are examples of bad conductors but asbestos, ebonite etc. are examples of insulators.

Semiconductor: Those bodies whose electrical conductivity or resistivity lies between the conductor and insulator are called semi conductors. At 0 K all semi conductors are insulators. In semi conductors the charge carriers are both electrons and holes (+ve ions).

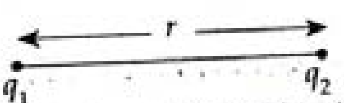
Germanium, silicon, selenium etc. are examples of semiconductors. On adding impurity in pure semiconductor its electrical conductivity increases too. If the temperature of a good conductor is increased, then its electrical resistance will increase, consequently its electrical conductance will decrease. But in a semiconductor with rise in temperature its resistance decreases and consequently its conductivity increases. That's why it is said that a semiconductor has negative temperature coeff. of the resistance while metallic conductor has a positive temperature coeff. of the resistance.

Surface charge density : The charge confined in unit area of any conductor is called surface charge density.

$$\text{Thus surface charge density} = \frac{\text{electric charge}}{\text{Area}}$$

The surface charge density of any conductor also depends on the shape and size, the presence of other conductor or on the electro resistive bodies. The surface charge density is obviously maximum at the pointed part of the conductor due to minimum surface area. Whenever the air particles come in contact with pointed charged conductor, then these are electrified and after repulsion get detached. To occupy the position of these air particles other air particles rush and this phenomenon occurs frequently. Thus, the detachment of air particles (electrified) form a phenomenon of convectional discharge and this convectional current is called electric wind.

Coulomb's law or Electrostatic force



If two stationary point charges q_1 and q_2 are kept apart at a finite distance r, then there exists a force of attraction or repulsion due to both point charges and this force is directly proportional to the product of charges q_1, q_2 and inversely proportional to the square of the distance r. This is called Coulomb's law.

Thus $F \propto q_1 q_2$, $F \propto \frac{1}{r^2}$

$$\Rightarrow \quad F = \frac{1}{4\pi\epsilon_0}\frac{q_1 q_2}{r^2} \quad \text{(In air or vacuum)}$$

[where; $\frac{1}{4\pi\epsilon_0}$ is called a constant $= 9 \times 10^9$ N.m^{2}coul.$^{-2}$]

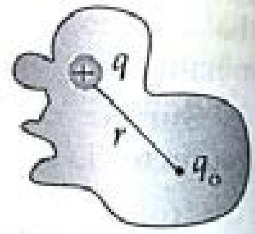
Here ϵ_0 is called the absolute permitivity of free space and its numerical value for air or vacuum is 8.85×10^{-12} coul. N^{-1}m^{-2}.

If q_1 and q_2 are the charges of like nature, then there will be a force of repulsion but for unlike nature there will be a force of attraction.

Importance of electrostatic force : In an atom the orbiting electrons and protons (part of massive nucleus) balance to each other by an electostatical coulombian force. Thus, atoms remain neutral. The molecules are composed through these atoms and the matter through the molecules. Thus, electrostatical force is significant among interatomic and intermolecular binding of matter. Also Coulomb's force is similar to the gravitational force and this force (weakest force) is only attractive in nature by the virtue of their masses (no concept of –ve mass) while coulombian force is both attractive and repulsive and predominants from any larger distance up to 10^{-14} m. For the distance of less than 10^{-14} m coulomb's force doesn't exist but nuclear force (strongest in the all forces) becomes operative which doesn't depend on the charges and distances.

Electric field Intensity or Electric field strength or Electric Intensity :

If in the electric field of a charged particle (say, q) any other unit positive test charge (say, q_0) is kept at any point then this test charge experiences a force and it is called electric field intensity of that point and it is a vector quantity and its direction is as that of the force (coulomb force)



Obviously $F = \frac{1}{4\pi\epsilon_0}\frac{q q_0}{r^2}$ Newton.

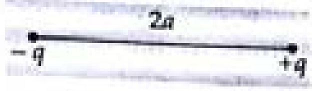
But the electric field intensity $(E) = \frac{F}{q_0} = \frac{1}{4\pi\epsilon_0}\frac{q}{r^2}$ N/coul.

Thus, SI unit of electric field intensity is Newton/coulomb. Another SI unit of it is volt/metre.

Electric field of a hollow conductor : The electric field inside a hollow conductor is zero. In fact whenever such conductor is electrified then the charges reside on the outer surface of the conductor. Thus hollow spherical body acts like an electrostatical shield. That's why if anybody is travelling in a car on a rainy day and an electrical lighting strikes the car then this will reside on the outer surface (roof of the car) and the traveller remains safe inside the car.

Electric dipole and electric dipole moment

If two stationary point charges of equal magnitude but of opposite sign are kept a small (short) distance apart, then this electrical configuration is called an *electric dipole.*

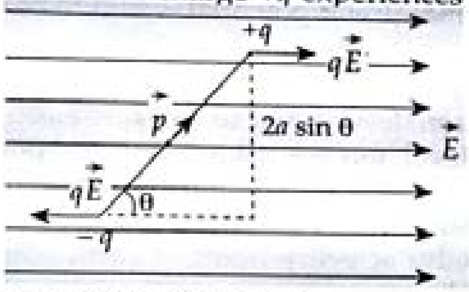


The product of the magnitude of the charge and the distance between both the charges is called electric dipole moment and it is represented by $\vec{p}$ and it is a vector quantity directed from −ve to +ve charge, along the dipole axis.

Thus, $\vec{p} = 2aq$ (electric dipole moment)

Electric dipole kept in an electric field

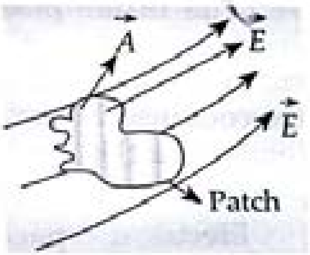
(i) If the field be uniform : If a dipole is kept in a uniform external electric field $\vec{E}$ making and angle θ with the field, then the charge $+q$ experiences a force $q\vec{E}$ in the direction of the field, while the charge $-q$ experiences an equal force in the opposite direction. Thus, there is no net force on the dipole. But these two equal and opposite forces form a couple which produces a torque and it tends to set the dipole in the direction of the field.



(ii) If the field be non-uniform : In a non-uniform field, the forces on the two charges will not be equal and opposite and so there will be a net force on the dipole and this force will also generate a couple and so a torque.

Thus, in non-uniform field a dipole experiences both a net force and a torque.

Electric flux : The electric flux is defined as the product of the electric field intensity and the outward normal area of any particular patch where an electric field is assumed to be confined.



It is represented by ϕ_E. Thus; $\phi_E = EA$. Its SI unit is N/coul.m^2 or volt-metre.

Gauss's law : Gauss's law states that electric flux ϕ_E through any closed surface is equal to $\frac{1}{\epsilon_0}$ times the net charge q enclosed by the surface.

$$\text{Thus } \phi_E = EA = \frac{q}{\epsilon_0}. \quad \Rightarrow \quad E = \frac{q}{\epsilon_0}\cdot\frac{1}{A} = \frac{q}{\epsilon_0}\cdot\frac{1}{4\pi r^2} = \frac{1}{4\pi\epsilon_0}\cdot\frac{q}{r^2}$$

(For the spherical surface $A = 4\pi r^2$)

where E = electric field intensity

This law gives a relation between the electric flux and the charge enclosed through any closed hypothetical surface (called Gaussian surface).

Gauss's law is the most fundamental law instead of coulomb's law due to certain conceptual advantages. The first advantage is that Gauss's law starts with the concept of electric field, which is more fundamental than the interaction of charges with which coulomb's law deals. According to modern field theory approach, the interaction between the two charges occurs abundently through the electric field. The second advantage is that all those results which were given by coulomb's law after tedious calculations were too complicated but it had much simpler way by Gauss's law.

Electric potential : The electric potential at any point is defined as the work done by an external agent in bringing a unit positive test charge from infinity to that point confined in an electric field.

Thus, if W work is done in bringing a unit positive test charge q_o from infinity to a point then electric potential at that point $= V = \frac{W}{q_o} \Rightarrow W = Vq_o$

S.I. unit of electric potential is Joule/coul. or volt. The special unit of electric potential is volt in the honour of an Italian scientist Alessandro Volta. The electric potential is a scalar quantity. If 1 coulomb +ve test charge is brought from infinity (∞) to any point and thus, does a work of 1 Joule then 1 volt potential is said to be confined at that point.

Zero potential : For the measurement of any physical quantity usually a standard parameter or reference point is taken, whose indicator reads zero level. Thus, to measure electric potential earth is taken to be a reference level and the value of electric potential at any point on the earth's surface is assumed to be zero. Our earth is a great conductor in which addition or subtraction of some charges do not change the value of its potential. That's why at every point of earth's surface electric potential is assumed to be always zero.

Potential difference or Potential drop : If in an electric field a unit positive test charge is carried out by an external agent from one point to another, then the work done in this process is called potential difference (p.d) between both the points.

The p.d. is measured in volt and it is also a scalar quantity.

The inside potential of a hollow conductor : Whenever a hollow conductor is electrified (charged), then the charges accumulate on the outer surface of the conductor and this charge doesn't enter the hollow part of the conductor. Thus there is no inside charge but the potential of this part (hollow part) is not zero. In fact every point inside the conductor has equal potential and it is equal to the potential of the conductor.

Electrical capacity and capacitor or condenser : When a conductor is given a charge, its potential rises in proportion to the charge given. Thus if a charge Q raises the potential of a conductor by V, then $Q \propto V$ i.e. $Q = CV$, where C is a constant depending upon the size and shape of the conductor, the surrounding medium and the presence of another conductors near by to it. This constant C is called electrical capacity or capacitance of the conductor.

Thus $C = \frac{Q}{V}$

S.I. unit of the electrical capacitance is coul./volt and its special name is *farad*.

It is also observed that farad is a too large unit and so in practice smaller units like microfarad and picofarad are used.

Thus we use; 1 microfarad ($1\mu f$) $= 10^{-6} f$.
1 picofarad ($1 pf$) $= 10^{-12} f$.

Capacitance of an isolated conducting sphere : Let us consider an isolated conducting sphere of radius r placed in vacuum (or air). Suppose it is given a charge q. This charge spreads on the surface of the sphere in such a way that all points on and inside the sphere are at the same potential.

The potential is given by $V = \frac{q}{4\pi \in_0 r}$

If C be the capacitance of the sphere then $C = \frac{q}{V} = 4\pi\in_0 r$.

$$\Rightarrow \text{capacitance } (C) = 4\pi\in_0 r.$$

This concludes that the capacitance of an isolated sphere is directly proportional to its radius.

Capacitor or Condensor : An isolated conductor has a very small capacity of storing the charges i.e. only very small amount of charges given to the conductor raises its potential by a large amount. If however a second earthed conductor is placed near it, then an equal and opposite amount of charges are induced on the front surface of the second conductor which lowers the potential of the first conductor. Thus capacitance of the conductor increases. Such a pair of conductors which can store a good amount of charge is called a *capacitor or condensor.* The conductors are called the plates of the capacitor. The net charge on a capacitor means the magnitude of charge on either plate.

There are broadly three types of capacitors—

(1) Parallel-plate capacitor $\left(C = \frac{\in_0 A}{d}\right)$

(2) Spherical capacitor $\left(C = 4\pi \in_0 \frac{ab}{b-a}\right)$

(3) Cylindrical capacitor $\left(C = \frac{2\pi \in_0 l}{\log_e\left(\frac{b}{a}\right)}\right)$

where,

A = area

d = plate separation

a, b = inner and outer spherical or cylindrical radii

l = length of the cylinder

Dielectric : A dielectric (an insulator) is a material in which all the electrons are tightly bound to the nuclei of the atoms. Thus there are no free electrons to generate the current. Hence, the electrical conductivity of a dielectric is very low. The conductivity of an ideal dielectric is zero. Glass, mica, plastic, oil etc. are examples of dielectrics.

Dielectric constant : When a dielectric material is kept between the plates of a capacitor, the capacitance of the capacitor increases. The ratio of the capacitance of a given capacitor with the material (dielectric) filling the entire space between its plates to the capacitance of the same capacitor in the vacuum is called dielectric constant or specific inductive capacity of the material. Thus, if C_d is the capacitance with dielectric material and C_o that of without dielectric in the vacuum, then dielectric constant $(k) = C_d/C_o$

The value of dielectric constant is independent from the shape and size of the capacitor, but its value varies widely for different materials.

For vacuum; $(k) = 1$ air ; $(k) = 1.006$ glass; $(k) = 6$ etc.

Nonpolar and polar molecules : The molecules of dielectrics are classified as *nonpolar* and *polar.* A nonpolar molecule is one in which the centre of gravity of the positive charges (protons) coincide with the centre of gravity of the negative charges (electrons). In other words, a polar molecule is one in which the centre of gravity of positive charges is separated from the centre of gravity of negative charges by a finite distance. The polar molecule thus acts like an electric dipole and has an intrinsic and permanent dipole moment. A nonpolar molecule has obviously a zero electric dipole moment.

Molecules having a symmetrical structure are nonpolar. Examples - H_2, N_2, O_2, CO_2, CH_4 etc. But molecules having spherical symmetry of atoms are polar. Examples- *HCl*, *CO*, H_2O, NH_3 etc.

Electric polarization of matter : When a dielectric material is kept in an electric field, the positive and negative charges of its (non-polar) molecules or atoms, experience electrostatic forces in the opposite directions. Thus, the centre of gravity of the two charges are separated from each other. The molecules thus acquire an induced electric dipole moment in the direction of the field. This phenomenon is called electric polarization of matter.

Section - B

Current Electricity

Metallic bodies have free electrons as charge carriers and between any two points which are at different potential electric charges move from a higher to a lower potential and for these charge carriers the direction of conventional current is that of the charge carriers. Since metallic bodies do not have any *+ve* charges as charge carriers but only electrons (–vely charge carriers) are charge carriers. That's why the conventional current is assumed to flow from a low potential to a high potential or opposite to the direction of flow of charge carriers (electrons) in metallic conductors.

Despite the magnitude and direction of the electric current, it is a scalar quantity because it doesn't obey the triangle law of vector addition or parallelogram law of vectors. Usually in solid conductors electric current is produced by the electrons, while in liquid it is produced through the ions and electrons and in semiconductor electric current is produced through both the charge carriers electrons and holes.

If in any electrical circuit the electric current is passed unidirectionally then it is called direct current (d.c.) but if electric current passes in the sinusoidal (plusuating) parallel form then it is called alternating current (a.c.). The electric current is measured in *ampere* and its another unit is coulomb/second. If in a metallic conductor (wire) 1 ampere electric current is passed then in every second 6.25×10^{18} electrons will enter from one end and the same number of electrons will be passed out.

Thus, an isolated metallic conductor (say wire) always contains some number of free electrons which are moving at random with high speeds which are called conduction electrons. When the ends of a wire are connected to a battery, an electric field is set up at every point within the wire. This field exerts a force on each conduction electron called electro motive force (emf). Thereby, the total number of free charges passing through any cross-section per second is the *electric current* in the wire. If a free charge *q* passes through any cross-section of the wire in time t, then the electric current i is defined as $i = \frac{q}{t}$.

Current density : The current per unit area of any cross-section of the conductor is called *current density*. It is the characteristic of a point inside a conductor (not the characteristic of the conductor as a whole). If the current is distributed uniformly across a conductor of cross-sectional area A, the current density at all points in that cross-section is given by

$$j = \frac{i}{A}$$

The current density is a vector quantity while current is a scalar quantity. Obviously, SI unit of the current density j will be ampere/metre^2 or couls/sec-metre^2.

Electric cell : The electric cell is an equipment which maintains a potential difference between any two points of the conducting wire so that the flow of electric current is continuously sustained. In electric cells the chemical energy which is produced by various chemical reactions transforms into electrical energy. There are two metallic rods in every electric cell which are called electrodes and which have opposite nature. The metallic rod which is +vely charged is called anode and collected ions are called anions, while the metallic rod which is −vely charged is called cathode and collected ions are called cations. These metallic rods (electrodes) are kept inside the solvent of the container called electrolyte.

Usually electric cells are of two types :

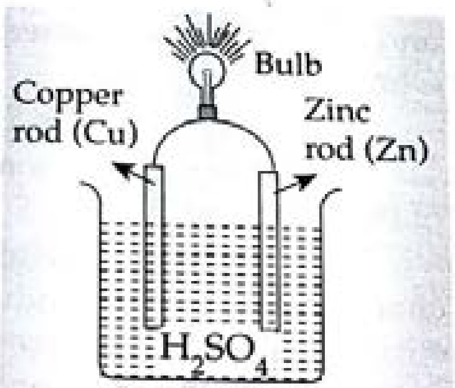
(i) Primary cell (ii) Secondary cell

(i) Primary cell : In a primary cell chemical energy is directly converted into electrical energy and when all the chemical energy is exhausted (used up) the cell becomes dead. The volta cell, Leclanche's cell, dry cell, Daniel's cell etc. are the examples of primary cell.

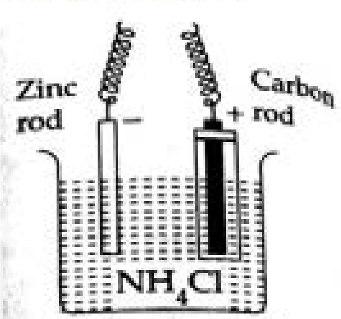
(ii) Secondary cell : In a secondary cell first the electrical energy is converted into chemical energy. Then this chemical energy is converted into electrical energy. The entire process is completed by charging and during its use it is discharged then it is again charged and this is the process (way) of its functioning. That's why all the secondary cells are rechargeable. The process of recharging is done through an external source of electrical energy. The battery or cell attached in motor vehicle, motor bike, emergency light etc. are the examples of secondary cell.

Voltaic cell : The voltaic cell was invented by Professor Alsendro Volta in 1799. In this cell a zinc rod and a copper rod are kept inside the glass container of sulphuric acid (H_2SO_4).

In this cell the copper rod acts like an anode and the zinc rod acts like a cathode. The value of emf in this cell is 1.08 volt.



Voltaic cell



Leclanche's cell

Leclanche cell : In this cell in a glass container a saturated solution of NH_4Cl is taken in which zinc rod acts like a cathode and carbon rod is kept in the mixture of manganese dioxide (MnO_2) which acts like an anode the value of *emf* is 1.5 volt. This type of cell is used where electric current is not regularly available. Such cells are mainly used in electric alarm, siren, telephone etc.

Dry cell : In this cell the electrolyte used is not in the form of solution but it remains in the dry form. In it there is a zinc container (vessel) in which manganese dioxide (MnO_2), ammonium chloride (NH_4Cl) and carbon are kept and in the middle of this mixture a carbon rod is kept. Here, the carbon rod acts like an anode while the zinc container acts like a cathode. The dense paste of amonium chloride is kept inside the mixture of MnO_2 and carbon. The value of *emf* of this cell is also 1.5 volt. Such cells are used frequently in torch, transistor, radio etc.

***Emf* of the cell :** Through any cell if 1 coulomb electric charge be circulated in a complete closed circuit, then the electrical energy supplied by the cell is called electromotive force (*emf*). The *emf* of the cell is measured in volt. The value of *emf* of the cell is always greater than the potential difference (pd) of the terminals of the cell or battery.

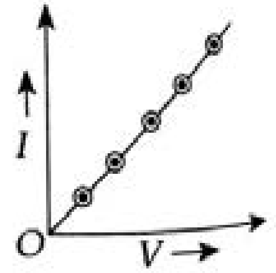
Electro Motive Force of cells

Cell	***EMF's***
Voltaic cell	1.08 volt.
Daniel's cell	1.08 volt.
Dry cell	1.50 volt.
Leclanche cell	1.50 volt.
Lead container cell	2.00 volt.
Battery of six cells	12.00 volt.

Internal resistance of a cell : The resistance produced by the electrolyte of the cell in the path of electric current is called internal resistance of the cell. If E, V and I are the *emf*, potential difference (pd) and electric current respectively, then the internal resistance of the cell is given by

$$r = \frac{E - V}{I}$$

Electric Conduction; Ohm's law : Firstly, a German physicist George Simen Ohm invented a relation between electric current and potential difference between any two points of a conductor. He stated that at a constant temperature the current passed through any conductor is proportional to the potential difference of any two points and this is called Ohm's law.



If V and I are the pd of any two points of a conductor and electric current passed through it, then according to Ohm's law

$$V \propto I \quad \text{i.e.,} \quad V = RI$$

where R is a proportionally constant called resistance of the conductor.

Thus, resistance of any conductor is the internal characteristic of the conductor which appears during the flow of electric current and which opposes it. In fact the free electrons which are the charge carriers of the metallic conductor (good conductor) collide with the another free electrons, atoms and molecules consequently the electrical resistance is produced (generated).

As from Ohm's law Resistance $(R) = \dfrac{\text{pot. difference } (V)}{\text{electric current } (I)}$

The S.I. unit of electrical resistance is ohm (Ω). The electrical resistance of any conductor depends on the following parameters;

(i) On the nature of the conducting materials.

(ii) On the temperature of the conductor—The resistance of the conductor increases on increasing temperature, and vice-versa. But in semi conductor the resistance decreases with rise (increase) in temperature.

(iii) On the length of the conductor—The resistance of the conductor is directly proportional to the length of the conductor. Thus resistance increases with rise of temperature of the conductor and vice-versa.

(iv) On the area of cross-section—The resistance of the conductor decreases with increase in the area of cross-section and vice-versa.

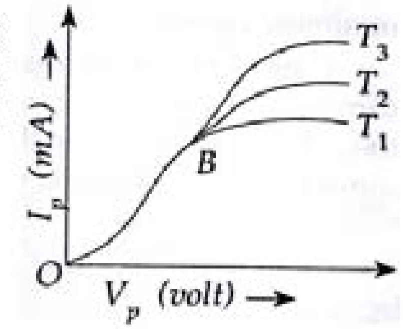
Ohmic resistance : The conductor which follows Ohm's law is called Ohmic resistor and the corresponding resistance is called Ohmic resistance.

Example – Manganese wire, copper wire, aluminium wire etc.

Non-Ohmic resistance : The conductor which doesn't follow ohm's law is called non-ohmic resistor and the corresponding resistance is called non-ohmic resistance. The non-ohmic resistor (non-linear curve) follows Child Langmuir's law.

Example– Diode valve, triode valve etc.

Child Langmuir's law (diode characteristic non-linear curve) : The diode doesn't follow (obey) Ohm's law but follows Child-Langmuir's non-linear law.



Here as shown in the curve the portion *OB* is the characteristic curve and Child-Langmuir's law in which the plate current (I_p) increases with the plate voltage (V_p) non-linearly and it is

$$I_p \propto V_p^{\frac{3}{2}}.$$

$$\Rightarrow I_p = k\, V_p^{\frac{3}{2}}$$

where, *k* is a proportionality constant. This is Child-Langmuir's law.

Specific resistance or resistivity : The electrical resistance of any conductor is directly proportional to the length of the conductor and inversly proportion to the cross-sectional area of the conductor.

Thus $R \propto \dfrac{l}{A}$ i.e. $R = \rho \dfrac{l}{A}$,

where, ρ is a proportionality constant called specific resistance.

The value of specific resistance or resistivity depends on the nature of the substance of the conductor and on the temperature.

If $l = 1$, $A = 1$ then $R = \rho . \dfrac{1}{1} = \rho$

Thus specific resistance of any conductor is resistance of the conductor if the conductor has unit length and unit area of cross-section. S.I. unit of specific resistance is ohm-metre (Ω-m). The smallest value of specific resistances is of silver. That's why it is the best conductor of the electricity.

Specific resistance of some substances

Substance	Sp. resistance on 0°C (in Ωm)	Substance	Sp. resistance on 0°C (in Ωm)
Silver	1.6×10^{-8}	Copper	1.7×10^{-8}
Aluminium	2.7×10^{-8}	Tungsten	5.6×10^{-8}
Iron	10×10^{-8}	Platinum	11×10^{-8}
Mercury	98×10^{-8}	Manganese	44×10^{-8}
Nichrome	100×10^{-8}	Carbon	3.5×10^{-5}
Germanium	0.46	Silcon	2.3×10^{3}
Wood	$10^{8} - 10^{-11}$	Glass	$10^{10} - 10^{14}$
Mica	$10^{-11} - 10^{15}$		

Electrical conductance : The reciprocal or inverse of the electrical resistance of any conductor is called electrical conductance.

$$\text{Thus electrical conductance } (ef) = \frac{1}{\text{electrical resistance } (R)}$$

S.I. unit of conductance is ohm^{-1} (Ω^{-1}) and it is also called *mho*, its S.I unit is *simen* (*S*).

Specific conductivity : The reciprocal or inverse of the specific resistance is called specific conductivity.

$$\text{Thus, specific conductivity } (\sigma) = \frac{1}{\text{sp. resistance } (\rho)}$$

S.I. unit of specific conductivity is ohm^{-1} metre^{-1} (Ω^{-1} m^{-1}) or *mho* metre^{-1} or simen metre^{-1}.

Combination of resistance : In order to obtain the derived current through the electrical circuit usually more than one resistors are used. If all the resistors enclosed in the circuit are replaced by a single resistor so that the same electric current be passed, then this resistance is called an equivalent resistance.

Usually in electrical circuits the grouping of the resistances take place by two ways –

(i) series grouping (combination) (ii) parallel grouping (combination)

Series grouping : If various resistors be connected in an electrical circuit in such a way that these resistors have various pd's but the same current through all the resistors then this grouping (combination) is called series grouping. By this grouping maximum resistance is obtained equivalentally.

If R_1, R_2, R_3, ... are various resistances connected in series, then the effective (resultant) resistance of the combination is

$$R_{eq.} = R_1 + R_2 + R_3 + \ldots\ldots\ldots$$

Parallel grouping : If various resistors are connected in an electrical circuit in such a way that these resistors have same pd but different electric currents. In order to obtain the minimum resistance such grouping (combination) is made.

If R_1, R_2, R_3 .... are various resistances connected in parallel, then the effective (resultant) resistance of the combination is

$$\frac{1}{R_{eq.}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \text{ ....}$$

Electric power : The rate of loss of the electrical energy in the electric circuit is called electric power. Electric power is defined as the product of electric current and pd of the two end points of any conductor.

Thus, electric power (P) = current (I) × pd (V)

$$\Rightarrow \qquad P = IV$$

SI unit of power is watt. Other larger units of the power are *kilo Watt* (kW) and *Mega Watt* (MW).

kW Hour or unit : 1 kWH (kilo Watt Hour) or 1 unit is that amount of electrical energy which is consumed in 1 hour through any electrical system (circuit).

Thus, 1 unit is the amount of electricity required which is obtained by utilizing a bulb of 100 watt in switching mode up to 10 hours.

If on any electric bulb there is a mark of 60W- 220 V then this implies that if the bulb is switched on 220 volt, then 60 watt power will be consumed every hour.

Example– 1 : If a 200 watt bulb is switched on upto 5 hrs. everyday then how many units power will be consumed everyday ?

Solution : Obviously power consumed $= \dfrac{200 \times 5}{100 \times 10} = 1$ unit.

Example– 2 : If an electric heater of 220 volt draws the current of 5 ampere, then in 5 hrs how many units power will be consumed ?

Solution : Here the required power consumed

$$= \frac{V.I.t}{100 \times 10} = \frac{220 \times 5 \times 5}{1000} = 5.5 \text{ units}$$

Effect of electric current : The electric current has various types of effect like magnetic effect, chemical effect, thermal effect etc.

Magnetic effect : Whenever an electric current passes through any conductor, then a magnetic field is produced (generated) around the conductor. In 1820 an observation was made by Oersted who saw that when a magnetic needle is brought near a current carrying wire (conductor), then it is deflected. But this needle only deflects in magnetic field which obviously confirms that current carrying conductor produces magnetic field. This is called magnetic effect of the current. The direction of magnetic field is given by Maxwell's Cork-Screw rule, Fleming right hand rule etc.

Maxwell's Cork-Screw rule (law) : If a cork-screw be taken in right hand and rotated in such a way that electric current is passed forward in the direction of the tip, then the direction of the thumb of the hand is along the positive direction of the magnetic lines of force.

Fleming's right hand rule : If the right hand is kept on a current carrying wire in such away that thumb, forefinger and middle finger are mutually perpendicular to each other and if forefinger is along the electric current and middle finger is along the deflection of the magnetic needle then the thumb of the hand is along the direction of the magnetic lines of force.

Lorentz force : When free charge carriers activate in a conductor, then an electric field is produced while if these free charge carriers start to move then electric current is produced and every current carrying conductor has a magnetic field. Thus, a moving charge particle has both electric and magnetic field and here, force experienced by the charge particle is both electric and magnetic which is called Lorentz's force.

Thus Lorentz's force $(F) = qE + qB \sin \theta$

where, q = charge on the particle
E = electric field intensity
v = velocity of the charged particle
B = magnetic field intensity. θ = angle between the velocity of charged particle and electric field intensity.

The direction of Lorentz's force can be determined by Fleming's left hand rule.

Electromagnet : If an insulated wire is wound around a cylindrical object, it is called a solenoid. The cylindrical object is called core. The solenoid whose core is made of soft iron is called electromagnet. The electromagnet is utilised in dynamo, transformer, electric alarm, telegraph and telephone etc. The temporary magnetism can only be achieved by soft iron. The magnetic field intensity of an electromagnet depends on the following parameters—

(i) No. of turns of the solenoid :

The magnetic field intensity of the solenoid $(B) = \mu_o \, i \, n$.

where, $\mu_o = 4\pi \times 10^{-7}$ (absolute permeability)
i = current
n = No. of turns per unit length.

Thus, if there is more no. of turns then magnetic field intensity will be large and vice-versa.

(ii) The nature of the core substance : If the core of the solenoid is made of soft iron then the magnetic field intensity will be large.

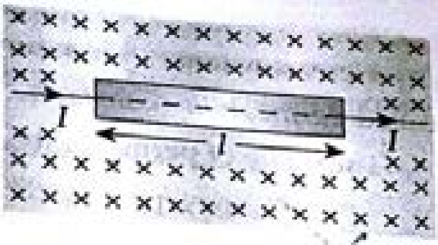
(iii) The magnitude of the electric current : The magnetic field intensity is directly proportional to the magnitude of the electric current. Thus, magnetic field intensity will increase with increase of electric current and vice-versa.

The force acting on a current carrying conductor in a uniform magnetic field : If I current is passed through a conductor of length l which is placed in a uniform magnetic field intensity B, then the force experienced by the current carrying conductor $= F = IlB \sin \theta$.

where, θ = angle between current carrying conductor and the magnetic field intensity.

Obviously if $\theta = 0^o$

then $F = 0$ i.e if current carrying conductor is in the direction of magnetic field intensity then no force would be experienced by the conductor.



But if $\theta = 90^o$

then $F = lIB$

Thus, maximum force will be experienced by the conductor if magnetic field is perpendicular to the conductor.

Magnetic Flux : If any surface be kept in a uniform magnetic field then the magnetic lines of force originating from that surface normally outward is called magnetic flux. It is represented by ϕ_m. S.I. unit of magnetic flux is weber (wb)

Mathematically, $\phi_m = BA$ weber

where, B = magnetic field intensity.

A = normal vector area.

Magnetic field : The region (space) around a magnet which has the magnetic effect is called magnetic field. A magnetic field is said to be existing at a point if it can exert a force on a current carrying conductor. The magnetic field has a unit normal area.

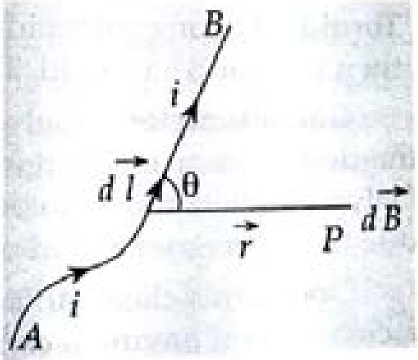
Units of magnetic field intensity (strength) : SI unit of the magnetic field intensity(strength) is *Telsa*. The magnetic field is also expressed in weber/metre^2. Thus, 1 Tesla = 1 weber/m^2. C.G.S. unit of magnetic field intensity is *Gauss*. 1 Tesla = 10^4 Gauss.

SI unit of magnetic field strength.

$$1 \text{ Tesla } (T) = 1\, NA^{-1}\, \text{m}^{-1} = 1 \text{ weber/m}^2 = 10^4 \text{ Gauss}.$$

Biot-Savart law : As Oerested observed a current carrying conductor produces a magnetic field around it. The magnitude and direction of this field at any point can be expressed by means of a law determined experimentally by Biot and Savart and it is called *Biot-Savart* law.

If AB is any conductor of an arbitrary shape carrying current i and P is any point in vacuum at which the field is to be determined. Here we divide the conductor into infinitesimal current element. Let $\vec{dl}$ be the length of one such element. Let $\vec{r}$ be the displacement vector from the element to the point P. Then according to Biot-Savart's law, the magnetic field induction $\vec{dB}$ at P due to the current element $\vec{dl}$ is given by



$$\vec{dB} \propto \frac{i\,\vec{dl} \times \vec{r}}{r^3} = \frac{\mu_o}{4\pi}\,\frac{i\,\vec{dl} \times \vec{r}}{r^3}$$

$$= \frac{\mu_o}{4\pi}\,\frac{i\,dl \sin\theta}{r^2}$$

Here, constant $\frac{\mu_o}{4\pi}$ is a dimensional proportionality constant, and μ_o is called *permeability constant*.

The value of permeability,

$$\mu_o = 4\pi \times 10^{-7} \frac{\text{weber}}{\text{ampere} - \text{metre}}, \quad \text{or,} \quad \frac{\mu_o}{4\pi} = 10^{-7} \frac{\text{weber}}{\text{ampere} - \text{metre}}$$

$$\Rightarrow \ d\vec{B} = 10^{-7} \frac{i\,dl \sin\theta}{r^2} \qquad \text{where,} \quad \theta = \text{angle between } d\vec{l} \text{ and } \vec{r}.$$

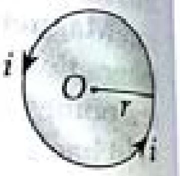
(i) Magnetic field due to a long straight conductor

Magnetic field induction $(B) = \frac{\mu_o}{2\pi}\frac{i}{R} = 2 \times 10^{-7} \frac{i}{R}$ weber/meter^2

where i = current through the conductor

R = distance from the current element to the magnetic field.

(ii) Magnetic field due to a current carrying circular coil : The magnetic field induction due to a circular coil of radius r at point O (centre of the coil)



$$B = \frac{\mu_o}{2} \cdot \frac{i}{r} \text{ weber/meter}^2$$

where, i = current through the coil,

r = radius of the coil

(iii) Magnetic field due to a solenoid : If there is a long solenoid of radius r meter carrying a current of i ampere in which n be the no. of turns per unit length then magnetic field induction at the mid point.

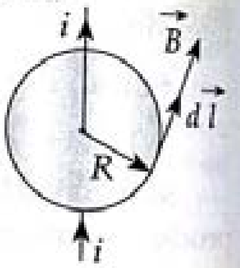
$= B = \mu_o\, i\, n.$ weber/meter^2

where, μ_o = permeability constant

$= 4\pi \times 10^{-7}$ weber/amp-m

i = current

n = no. of turns per unit length



Ampere's law : Ampere's law is the counterpart of the Gauss's law in magnetism. It states that the line integral $\int \vec{B} \cdot d\vec{l}$ for a closed curve is equal to μ_o times the net current i through the area bounded by the curve.

Thus; $\int \vec{B}\, d\vec{l} = \mu_o i$

Toroid : If a long solenoid is wrapped around in the form of a closed ring then it is called a toroid. Thus a toroid acts like an endless solenoid.

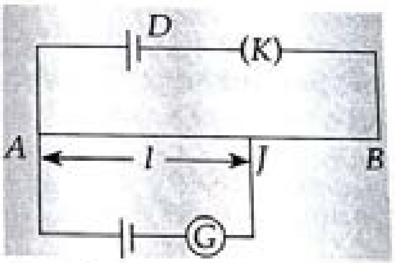
Galvanometer : Galvanometers are the electrical devices used for the detection or measurement of the electric currents. The action of these Galvanometers is facilitated by the torque experienced by a magnetic needle due to the magnetic field of a current loop.

One of this class galvanometer is a tangent galvanometer consisting of a circular coil having a compass needle at its centre. The frame containing the coil can revolve about the vertical axis. The compass box consisting of a ll magnetic needle is pivoted at the centre of the coil. A long aluminium er is attached at right angles to the needle, which moves over the graduated circular scale. The scale is divided into four quadrants reading from 0° to 90°. The needle and scale are enclosed in a flat casing provided with a glass top so that the scale needle and pointer may be visible from outside.

Shunt : Shunt is an electrical system of configuration of the electric conductor or wire of small resistance. Sometimes it is not desirable to send heavy electric currents through a sensitive Galvanometer and thus in order to protect such Galvanometer a low resistance wire or conductor is attached in parallel to the coil. Shunt decreases the effective resistance of the instrument. It increases the current measuring range but decreases the sensitiveness of the instrument.

Ammeter : Ammeter is a current measuring device and can measure a high current. Basically it is a low resistance moving coil galvanometer. It is always connected in series in the electrical circuit in which the current is to be measured. An ideal ammeter is one which has zero resistance. In fact an ammeter of low resistance is more accurate although it is less sensitive.

Voltmeter : Voltmeter is a potential difference (pd) measuring device and basically it is a high resistance moving coil galvanometer. It is always connected in parallel to the resistance across which p.d. is to be measured. Its reading is not accurate because it draws current so the p.d. across the resistance decreases (since the current through it decreases). Hence a voltmeter of high resistance is more accurate. In fact an ideal voltmeter is one which has infinite resistance and it measures accurately, although no current is passed throught it.

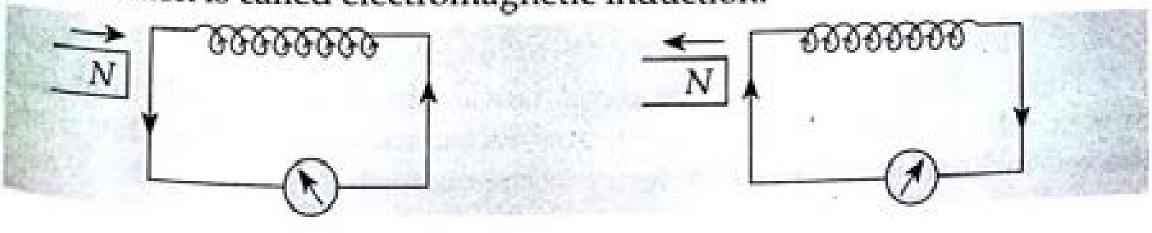


Potentiometer : Potentiometer is a device to measure the *emf* of a cell or p.d. between the ends of a current-carrying conductor without drawing any current from the circuit. It operates on the principle that an *emf* or p.d. can be balanced against another *emf* or p.d. which produces a zero current.

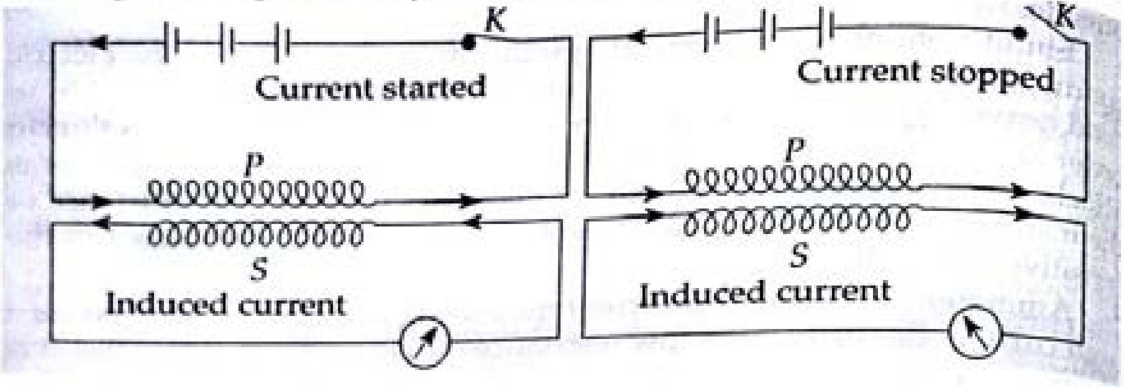
In a potentiometer the *emf* of a battery *D* (called the driving battery) is distributed over a long uniform wire *AB* of high resistivity and p.d. between any two points of it (one fixed at the left end *A* and other is sliding) is applied against *emf* or p.d. to be measured. The sliding point *J* is then moved over the wire, until both are balanced to each other. A sensitive galvanometer indicates whether the current in the circuit is zero or not.

When there is no deflection in the galvanometer then p.d. between *A* and *J* = *emf* of the test cell.

Electromagnetic induction : Faraday in 1831 discovered that whenever the magnetic flux (number of lines of induction) passing through a circuit changes, an *emf* is produced in the circuit. If the circuit is closed, a current flows through it. The *e.m.f.* and current so produced are called *induced emf* and induced current, while the magnetic flux regularly changes. This phenomenon is called electromagnetic induction.



The magnetic flux through a circuit may be changed in a number of ways, e.g. by moving a magnet relative to the circuit, by changing current in a neighbouring circuit, by changing current in the same circuit.



Faraday's laws of electromagnetic induction :

First law : When the magnetic flux through a circuit is changing, an induced *emf* is setup whose magnitude at any instant is equal to the negative rate of change of magnetic flux. This is also called Neumann's law.

Thus if ϕ_B be the magnetic flux linked with the circuit at any instant and ε the induced emf, then

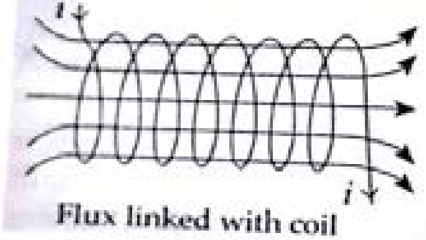
$$\varepsilon = -\frac{d\phi_B}{dt} = -\frac{d(BA)}{dt} = -Blv$$

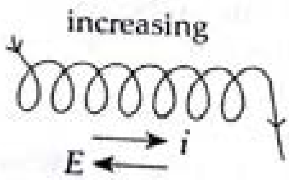
where, B = magnetic field, l = length of the conductor,
v = velocity of induced charge.

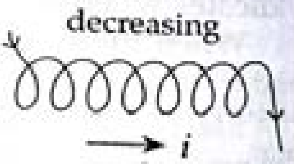
Second law : The direction of the *induced emf* of the electric current is such as to oppose the change that produces it. This is called *Lenz's law.*

The phenomenon of electromagnetic induction is frequently used in various devices like in artificial pacemaker, Dynamo, transformer etc.

Self-induction : When an electric current flows through a coil, it produces a magnetic flux which is linked with the coil. If the current through the coil is changed, the flux linked with the coil also changes. An induced *emf* E is therefore set up in the coil. By Lenz's law the direction of the induced *emf* is such as which opposes the change of the current.







Thus, the induced *emf* is against the current when the current is increasing and it in the direction of the current when the current is decreasing. This phenomenon is called *self induction* and the *induced emf* is called *back emf.*

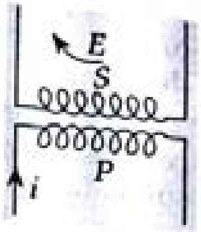
Thus, when the current in a coil is switched on, the self induction opposes the growth of the current, and when the current is switched off, the self-induction opposes the decay of the current.

If ϕ_B be the magnetic flux (flux linkage) of the coil then current induced in the coil is directly proportional to it.

$\Rightarrow \phi_B \propto i$ i.e. $\phi_B = L\,i$

Here L is a constant called coeff. of self-inductance.

SI unit of self-inductance is henry. Also another unit of self-inductance is volt-sec/amp.



Mutual Induction : Whenever the current passing through a coil changes, the magnetic flux due to the current, which may be linked also with a neighbouring coil, changes. Hence an induced *emf* is set up in the neighbouring coil. This phenomenon is called *mutual induction*. The coil in which the current changes is called *primary* coil, while the other in which the *emf* is set up is called *secondary coil.*

Also for the two given coils situated in a fixed relative position, flux linkage through the secondary is proportional to the current i in the primary.

Thus $N_s\,\phi_B \propto i$, i.e., $N_s\,\phi_B = Mi$

Here proportionality constant M is called coeff. of mutual induction.

SI unit of mutual induction is also *henry*. Another SI unit of mutual induction is volt-sec/amp.

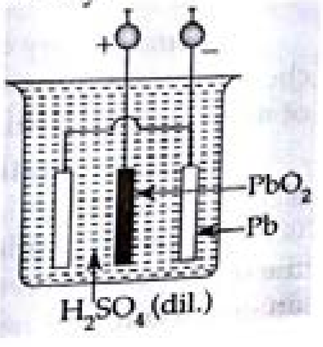
Chemical Effect : Pure water is a bad conductor of electricity, but if some metallic salt, acid or alkali are dissolved in it then water becomes good conductor of electricity. Thus, those solutions in which electric current can pass are called electrolytes. Thereby, whenever in any aqueous solution of salt, acid or alkali an electric current is passed and if these solutions decompose into +ve and −ve ions then this is called chemical effect of the electric current and the phenomenon is called electrolysis. The equipment in which electric decomposition occurs is called voltameter. Two metallic conductors which are kept at the entrance and exit of the voltameter are called electrodes. The electrode through which electric current enters inside the voltameter is called anode, while the electrode through which electric current comes out is called cathode. Thus +ve electrode is anode and −ve electrode is cathode. Whenever an electric current is passed through the any electrolyte, cations flow towards the cathode and anions flow towards the anode during the electrolysis.

Accumulator or secondary cell : In accumulator cell electrical energy is stored up in the form of chemical energy and when this accumulator cell is connected through any circuit then the stored chemical energy is being start to transform into electrical energy, slowly and steadily.

The accumulator cell is of two types—

(i) Lead accumulator cell

(ii) Alkaline accumulator cell



(i) Lead accumulator cell : There are two lead plates which are kept inside a dilute H_2SO_4. On supplying electric current the water is decomposed and H_2 accumulates on the cathode and O_2 at the anode. Oxygen (O_2) on being mixing with the lead of anode forms lead peroxide (PbO_2) which has a sharp brown colour. After sometime the electric current is stopped and at this moment the cell is electrified (charged) and its p.d. is of 2 volt. When this cell is connected with any conductor then in the external circuit current flows from anode to cathode. Consequently H_2 moves towards the plate of lead peroxide (PbO_2) and it transforms lead peroxide into lead monoxide (PbO) which reacts with sulphuric acid and forms lead sulphate and water. By the formation of water the specific gravity (density) is decreased. That's why cells become discharged.

A fully charged cell has the value of *emf* as 2.2 volt while discharged cell has its value as 1.8 volt. The position of the discharged cell is called sulphating.

(ii) Alkaline accumulator cell : In this cell potassium hydroxide (KOH) in concentrated form is kept inside a glass container. The anode of this cell is made in the form of pointed holes frame of steel in which Nickel hydroxide and the filings of nickel are accumulated in a crossed way. Another plate of porous steel in which powder of Iron-oxide is kept and this plate acts like the cathode. This cell is also called *Adison's cell* or *Nife (Ni-Fe) cell.*

Whenever an electric current is passed through an external source then an electric decomposition takes place and finally K^+ is accumulated on the cathode while OH^- is accumulated on the anode. Thus, cell is liquefied and an oppositely produced *emf* becomes effective and stable. Now if this cell is kept inside an electric circuit then the current flows and K^+ and OH^- liberate on the anode and cathode respectively. A fully charged cell has the value of *emf* as 1.35 volt while a discharged cell has the value of *emf* as 0.9 volt. The value of the internal resistance of the cell is 0-1Ω.

Efficiency of a cell : The efficiency of a cell is defined as the ratio of total beneficial work and total work done.

i.e. efficiency of a cell = beneficial work / total work.

Thus if in any cell the value of *emf* is E and in a closed circuit if p.d. of the terminals of the cell is V then

efficiency of the cell = V/E

Applications of electrolysis

(i) Extraction of metals : The metals like aluminium, sodium, calcium, magnesium etc. are extracted from their respective salts by the process of electrolysis. The electrodes are made of these metals and when an electric current is passed through the salts of these metals then pure metals are deposited on the cathode.

(ii) Analysis by electrolysis : By the basic principle of electrolysis some chemical compounds are analysed. The structure and chemical composition of the compounds like *HCl, HCN, HBr* etc are investigated.

(iii) Electroplating : On the basis of the principle of electrolysis electroplating (thin layer of any metal is coated on another metallic body) is done. The metallic body which is to be coated acts like an anode and the metal whose layer is to be coated on another acts like a cathode. Thus n electrolyte cell is formed and the process of electrolysis occurs. When the electric current flows through the electrolyte then the metal from the anode starts to dissolve in the solution and deposits on the cathode. Thereby, after sometimes a thin layer is to be coated on the cathode and ultimately metal is coated. For electroplating (coating) usually metals like gold, silver, platinum, nickel, zinc, chromium etc are used.

(iv) Electro-typing : Today in a large printing press by the use of copper voltmeter on behalf of the cathode printing papers are kept and after a short time a thin layer of copper is coated. Thus excellent prints appear on these copper coated papers.

(v) Electrolytic capacitor (condensor) : In such capacitor (condensor) both electrodes are made from aluminium. The mixture of boric acid, glycerine and acqeous ammonia act like an electrolyte and when an electric current is passed through it then a layer of aluminium hydroxide deposits on the anode. This layer acts like a dielectric for both the electrodes.

(vi) Purification of metals : For the purification of metals the anode is made of impure metal and the cathode is made of pure metal. The electrolyte is made through a liquified impure metal. When an electric current is passed through it then pure metal starts to deposit on the cathode of pure metal and thus purified metals are obtained. By this process copper can be purified upto 99.99%.

Thermal effect (heating effect) : When charge carriers (free electrons) move in the metallic conductor, then the electric current is produced in the conductor. These charge carriers move and collide with the atoms present in the conductor and transfer some of their kinetic energy to the atoms and these atoms collectively raise the temperature and the conductor becomes heated. Also the atoms of the conductor retard the speed of charge carriers. Thus, resistance is generated inside the conductor. This phenomenon of raising the temperature of the conductor is called thermal (heating) effect of the electric current. This phenomenon was fully explained and observed by Joule, so it is also called Joule's heating effect. He explained that if I electric current is passed through any conductor of electric resistance R up to t time, then Joule's heating energy of the conductor is

$$H = I^2Rt \text{ Joule (SI unit)}$$

Thermo electricity : If some metallic wires (conductors) are heated under some specific conditions, then electric current is generated. This is called thermoelectricity. There are various parameters and circumstances under which thermoelectricity is studied.

Seeback's effect : When two different metallic wires (conductors) are connected to each other and two junctions are formed by a differential heating or a temperature difference is maintained, then an electric current is generated (produced) through this couple, which is called seeback's effect. The current produced is called thermo-electric current. The corresponding *emf* is called thermo electromotive force.

Seeback's effect was displayed by making thermo couple of different metals of differential heating or by maintaining a constant temperature difference.

Seeback formed the following series of metals for thermoelectric couple by two different metals.

1. Antimony 2. Iron 3. Zinc 4. Silver 5. Gold 6. Tin
7. Lead 8. Copper 9. Platinum 10. Nickel 11. Bismuth

In a thermoelectric couple there are two junctions from where thermoelectric current passes. For examples– thermoelectric current flows from antimony to bismuth through cold junction (*abc*) but from copper to iron (*Fe*) through hot junction (Hot *CoFe*). Thus from bismuth to antimony thermoelectric current will flow through hot junction, while from iron to copper it will flow through cold junction.

Peltier effect : It is the inverse of the seebeck effect. When two different metals are joined to form a thermoelectric couple in such a way that an electric current is passed, then on the junction either heat is emitted or absorbed. Through any junction if the electric current flowing in a particular direction produces the heat, then in the opposite direction through the same junction heat is absorbed. This is called peltier effect.

Thomson effect : When a current flows through an unequally heated metal, there is an absorption or evolution of heat throughout in the metallic body. This is called Thomson effect.

In case of a copper or antimony rod whose ends are maintained at a temperature difference, heat is absorbed when the current flows from a cold to a hot end, and is evolved when the current flows from a hot to a cold end and here the Thomson effect is said to be positive. But in the case of an iron or bismuth rod, heat is involved when the current flows from a cold to a hot end and vice-versa and Thomson effect is said to be negative.

Applications of thermal effect : The thermal effect of the electric current are intensively used in electric heater, electric press, electric bulb, tube-lights etc.

Electric Heater : In an electric heater an aliment (thick coil) of nichrome (alloy of nickel and chromium) is kept inside the frame like plate which are made of plaster of paris. When an electric current is passed through the thick coil of nichrome, then due to the large electrical resistance the current remains confined for a longer time within the aliment and due to Joule's heat it becomes red heated and supplies a tremendous amount of thermal energy. In the position of red heated condition the temperature of the thick coil goes upto 800°C to 1000°C. Thus for a good electric heater the aliment must have a large electrical resistance and at such high temperature oxidation must be avoided.

Electric Iron : In an electric iron the nichrome wire or coil is wound upon a thick mica sheet. As the mica has good electrical resistance and doesn't melt at high temperature consequently this sheet or plate enclosing nichrome coil is kept on the upper surface of a steel slab. On the whole mica sheet-steel slab system, a hand keeper is attached which is made of wood or good quality fibre or of any others which are bad conductors. Whenever an electric current is passed through the nichrome coil, the base of the steel slab is heated and the clothes and garments are pressed.

Electric Bulb : The electric bulb was firstly invented by Thomas Alva Edison. The bulb is evacuated (vacuum created) and a filament of tungsten metal is attached to it. Along with evacuation a small amount of inert gases like argon or krepton is kept inside the bulb. Doing so the filament of the tungsten doesn't burn or vapourises. At high temperature tungsten vapourises and sometimes the inside walls of the bulb is blackened which is called blackening. Those metals are used in making the filaments of the bulb which have high melting point and high atomic weight. Since tungsten has very high melting point as 3500°C, the filament of a bulb is made of it. On passing the electric current normally the bulb's filament acquires the temperature from 1500°C to 2500°C. In ordinary bulbs only 5% to 10% electrical energy is converted into light energy, while the rest is destroyed in the form of thermal energy.

Tube light : Basically it is a long tube of glass and the inside wall of the tube is coated with a thin layer of fluorescent material. The tube glass has mercury which is mixed up along with some inert gas like argon inside it. The two ends of the tube have two terminals on which a thin layer of barium oxide is coated. Whenever these two terminals of the tube are activated to pass an electric current, then electrons are emitted which are directly respondent to ionise the gas present inside the tube. Consequently through ionisation of the gas, ions generate a flow of current inside the tube. The mercury confined inside the tube gets sufficient thermal energy and it (mercury) starts to vapourise and finally due to the electron emission *UV*–rays are emitted. When these *UV*–rays incident on the inside wall of the tube on which fluorescent material is coated, then *UV*–rays are absorbed by the wall and a visible ray or light of lower frequency seems to be appear.

The fluorescent material coated is used in such a way that light produced from the tube light appears similar to a white visible sunlight. In the tube light thermal energy is produced in smaller amount, so 60% to 70% electrical energy transforms into light energy. That's why the power of tube light is more sharp than an ordinary bulb. A 40 watt tube light provides 6 to 8 times more light than an ordinary bulb of 40 watt.

Alternating current (*A.C.*) **:** An alternating current is one which periodically changes in magnitude and direction. It increases from zero to a maximum value, then decreases to zero and reverses in direction, increases to a maximum in this direction, and then decreases to zero. The complete set of variations is known as a *cycle*. Thus, during one half of the cycle the current flows in one direction, and following the half-cycle it flows in opposite direction.

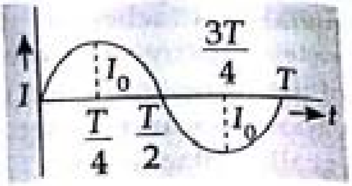
The simplest type of alternating current is one which varies with time simple harmonically. It is represented by the equation

$$I = I_0 \sin wt :$$

where I is the instantaneous value of the current at time t and I_0 is the maximum or peak value of the current.

This type of A.C. is called sinusoidal alternating current. It is represented by a sine curve.

The time taken by an A.C. to go through one cycle of changes is called its *period T*.



Thus time period T of an A.C. is $\frac{2\pi}{w}$. The number of cycles gone through an A.C. per second is called its *frequency*.

Here the frequency n is given by $n = \frac{1}{T} = \frac{w}{2\pi}$

Peak value of an Alternating current : An alternating current varies periodically from a maximum in one direction through zero to a maximum in the opposite direction and so on. The maximum value of the current in either direction is called *peak value* I_0.

Root mean square (rms) value or virtual value or effective value of the current : The root-mean square value of an alternating current is defined as the square root of the average or of mean of the I^2 during a complete cycle, where I is the instantaneous value of the alternating current.

The root-mean square value of the alternating current is given by

$$I_{rms} = \sqrt{\overline{I}^2} = \frac{I_0}{\sqrt{2}} = 0.707\ I_0$$

Thus the *rms* value of the alternating current is 0.707 times or 70.7% of the peak value I_0 of the current.

Similar to the above the rms value of an alternating voltage or alternating pd (*emf*) will be

$$V_{rms} = \sqrt{\overline{V}^2} = \frac{V_0}{\sqrt{2}} = 0.707\ V_0$$ where V_0 = peak value of the voltage.

Mean or average value of an alternating current : As an alternating current is represented by $I = I_o \sin \omega t$

So the mean value of the current over a complete cycle is zero and it has no significance. Hence the mean value of an alternating current is defined as its average over half a cycle.

The average or mean value of an alternating current = $I_{mean} = \frac{2}{\pi} I_0$.

Thus the average current during one positive or negative half cycle of an alternating current is $\frac{2}{\pi}$ times the peak value of the current I_0.

Similar to the above average or mean value of an alternating voltage or alternating pd (*emf*) will be = $V_{mean} = \frac{2}{\pi} V_0$.

Miscellaneous

In an A.C. circuit rms values of the electric current and voltage are used frequently and thus rms value or virtual value has its practical aspect.

In India the peak value of domestic supply is ± 311 volt and its frequency is 50 Hz.

In comparison to the direct current (dc) alternating current (ac) is more dangerous at the same voltage because real value of 220 V A.C. supply is ± 311 volt while 220 volt d.c. remains 220 volt only.

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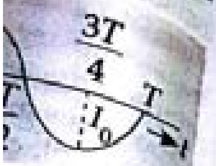

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A.C. Ammeter & Voltmeter : Since in an alternating current (a.c.) for a complete cycle or time period value of current is zero. Thus if an alternating current is passed through the d.c. devices, ammeter or voltmeter, then indicators of these devices will remain on zero. That's why to measure alternating current or voltage hot wire instruments like ammeter and voltmeter are used. By the indicator reading of hot wire ammeter we get the rms value directly. Similar to it by hot wire voltmeter rms value of alternating voltage is obtained.

Power, Power factor and wattless current

Power in A.C. circuit : The power in an electrical circuit is the rate at which the electrical energy is consumed in the circuit, and is equal to the product of the voltage and current. In A.C. circuit the instantaneous values of the voltage and current are given by

$$V = V_0 \sin \omega t \text{ and } I = I_0 \sin(\omega t - \phi)$$

where ϕ is called phase difference between the current and voltage.

The power in A.C. circuit $= I_{rms} V_{rms} \cos \phi$.

Thus average power $(\overline{P})$ = virtual current × virtual voltage × $\cos \phi$.

Power factor : As above $\cos \phi$ is the factor through which the product of the rms values of the voltage and current must be multiplied to give the power dissipated and it is called power factor of the circuit.

Wattless current : The current in A.C. circuit is said to be wattless when the average power consumed in the circuit is zero. Thus it is possible when the power factor ($\cos\phi$) is zero.

This implies that $\cos \phi = 0$ i.e. $\phi = \frac{\pi}{2}$ (90°)

Thereby, current will be wattles if the current and voltage differ in phase by $\frac{\pi}{2}$ or 90°.

In pure inductor the current lags behind the voltage by $\frac{\pi}{2}$ or 90°, that's why average power absorbed in a pure inductor is zero. Similarly in pure capacitor the voltage lags behind the current by $\frac{\pi}{2}$ or 90° and so in a pure capacitor average power absorbed is also zero.

Comparison of an alternating current (A.C.) with respect to a direct current (D.C.)

(i) The phenomenon of electrolysis cannot be performed through an a.c. current, so for the extraction of metals in metallurgy and other works in the industrial workshops are not to be done by a.c., and only d.c. is used.

(ii) In electroplating a.c. is not used and it can also be done by d.c. only.

(iii) The a.c. cannot be stored like d.c. in accumulator cell.

(iv) Electromagnets can only be prepared through d.c. and through an a.c. no electromagnet can be prepared.

Choke-coil : Often in a.c. it is required to reduce the current in a circuit fed by a.c. mains. This can be done through a d.c. circuit by inserting a resistance in the circuit. Although there is a wastage of energy (i^2R per second) in the form of a Joule's heat. In an a.c. circuit the current can be alternatively be reduced by inserting a coil of thick copper wire wound closely in a large number of turns over soft-iron laminated core. Such a coil offers a large reactance ($L\omega$) and contributes to the impedance (resistance in a.c.) of the circuit. Hence it reduces the a.c. appreciably. Such a coil is called Choke-coil.

The average power dissipated in the choke coil is $\overline{P} = \frac{1}{2} V_0 I_0 \cos\phi$

and the power factor is $\cos\phi = \frac{R}{\sqrt{R^2 + L^2 \omega^2}}$

Here the inductance L of the choke coil is quite large on account of its large number of turns and the high permeability of iron core, while its resistance R is very small. Here $\cos\phi$ is nearly zero. So the power absorbed by the coil is extremely small and thus choke coil reduces the strength of the current without appreciable wastage of energy. The only waste of energy is due to the hysteresis loss in the iron core. The loss due to eddy currents is minimised by making the core laminated. The choke-coils are used in electrical appliances like in tube light, radio, electric fan etc.

Preference of a choke-coil over an ohmic resistance : The current in an a.c. circuit can also be diminished by using an ordinary ohmic resistance (rheostat) in the circuit. But such a controlling method of a.c. is not economical as much of the electrical energy (i^2Rt) supplied by the source is wasted as heat. Hence a choke coil is preferred over the ohmic resistance.

Transformer : A transformer is an electrical device which converts a large alternating current (a.c.) into a small alternating current (a.c.) at high voltage (a.c.) and vice-versa. The transformers which convert a low voltage into a higher ones are called *step up* transformers, while those which convert a high voltage into a lower ones are called *step down* transformers.

A simple transformer consists of two coils— called *primary* and *secondary*, which are insulated from each other and which are wound on a common soft-iron laminated core. The alternating voltage to be transformed is connected to the primary, while the load is connected to the secondary. In a step-up transformer the primary coil consists of a large number of turns of thin insulated copper wire, while reverse is the case in a step-down transformer.

When an alternating voltage is applied to the primary, an alternating current (a.c.) flows in the coil. This sets up an alternating magnetic flux in the core. This magnetic flux is linked up with both the primary and secondary. Hence an induced alternating *emf* is produced in the primary as well as in the secondary.

If in a transformer, the no. of turns in primary and secondary coils are N_p and N_s and V_p, V_s are the induced *emf's* in primary and secondary coils then for an ideal transformer.

$\frac{V_s}{V_p} = \frac{N_s}{N_p} = r$ (say), called transformation ratio.

Obviously, if $N_s > N_p$ ($r > 1$), then $V_s > V_p$.

At this position transformer is called step-up transformer.

But if $N_p > N_s$ $(r < 1)$, then $V_p > V_s$.

At this position transformer is called step-down transformer.

Also, if I_p and I_s is the induced alternating current (a.c.) in primary and secondary coil

$$\text{then} \quad \frac{V_s}{V_p} = \frac{N_s}{N_p} = \frac{I_p}{I_s}$$

Energy losses in a transformer : The power output of a transformer is necessarily less than the power input because of unavoidable energy losses. There are three to four types of losses—

(i) Copper losses : As an alternating current flows through the primary and secondary, heat is developed inside the copper turns. This wastage of energy is called copper losses.

(ii) Eddy current losses : Eddy currents are set up in the iron core of the transformer, and these generate heat, with a consequent loss of energy. To minimise these losses the iron core is laminated by making it of a number of thin sheets of iron insulated from each other, instead of making it from one solid piece of iron.

(iii) Hysteresis losses : During each cycle of a.c. the core is taken through a complete cycle of magnetisation. The energy spent in this process is finally converted into heat and so wasted. This loss is minimised by being using the core of a magnetic alloy for which the area of the hysteresis loop is the minimum.

(iv) Losses due to flux linkage : In an actual transformer all the flux linked with the primary doesn't pass through the secondary, but some returns through air (that part of the flux which links both primary and secondary) is called mutual flux. The part linking the primary only is the primary linkage flux and the part linking the secondary only is the secondary linkage flux. The loss due to this is minimised by eliminating the air gaps in the magnetic circuit, by using core of a particular shape, and by having special forms of coil windings.

Uses of transformers :

(i) The step-up and step-down transformers are extensively used in A.C. electrical power distribution for domestic and industrial purposes.

(ii) An audio frequency (20 - 1600 Hz or cycles / sec) transformer which is essentially a step-up transformer is used in radio receivers, radio telephony, radio telegraphy and in television.

(iii) A radio-frequency transformer is used in radio-communication at frequencies of the order of mega-cycles.

(iv) Impedance transformers are used for matching the impedance (resistance of a.c.) between two circuits in radio communication.

(v) Pressure transformers are used for measuring very large alternating currents. The current to be measured is passed through the primary of a step-up transformer, the secondary being connected to an A.C. ammeter.

(vi) Current transformers are used in measuring a very high voltage. The voltage to be measured is stepped-down by means of the transformer, the secondary of which is connected to an A.C. voltmeter.

(vii) The constant pressure and constant voltage transformers are designed to give a constant output current and voltage respectively even when input voltage varies considerably.

Dynamo (A.C. generator) : Dynamo (A.C. generator) is a device by which mechanical energy is converted into electrical energy and it operates (works) on the principle of electromagnetic induction. If the coil of wires is rotated through a permanent magnetic field, then an induced current is produced. The dynamo supplies alternating current (a.c.) to the external circuit. If in dynamo (A.C. generator) on behalf of slip rings split rings are used, then it acts like a D.C. generator and in the external cricuit direct current (dc) flows out.

Microphone : Microphone is an acoustical device which transforms sound energy into electrical energy and consequently voice or sound is reached from one to another place. The microphone works on the principle of electromagnetic induction. In its basic composition carbon granules are attached in the middle of two metallic plates. In two metallic plates one is fixed and another is flexible and it is called diaphram. Whenever any vocalist speaks, then diaphram starts to vibrate and along with diaphram an attached coil with itself which is kept inside a magnetic field also vibrates. Consequently an electromotive force (*emf*) produces and the value of this feeble *emf* is strengthened by a step-up transformer. Now this electrical energy (due to strengthen *emf*) is converted into sound energy by the help of a loudspeaker or telephone receiver at the suitable places wherever required.

Loudspeaker : Loudspeaker is also an acoustical device through which the electrical energy is compressed and induced by the microphone which is converted into the sound energy in amplified and loud form. Simply in a loudspeaker there is a coil which is kept in the powerful magnetic field, and this field is generated by an electromagnet. The coil of the loudspeaker is attached with a cylindrical thick paper or with a metallic cylinder and it is called diaphram. When the induced current from the microphone is passed through the coil, then the diaphram whose shape and size is large starts to vibrate (oscillate) with a larger amplitude. That's why we hear a sharp sound.

Electric Motor : An electric motor is a device which converts electrical energy into mechanical energy. The magnetic field is produced by the electric current passing through the conductor only and by this magnetic field a motion is generated in the conductor. On this principle the electric motor works. This concept was first propounded by Michael Faraday. In an electric motor a rectangular coil of wire is wound on an armature and this armature is free to rotate on the axis of the poles of the magnet. Whenever an electric current is passed through the coil, then the magnetic field forcibly pushes the coil of opposite sides up and down. Consequently the coil rotates towards the right hand but due to directional polarity the coil changes the direction of rotation after completing half the rotation, and now forces operative on the sides of the coil are reversed. Thus, a couple (moment of force) is generated and electric motor remains operationalized. Thus, here we observed that electric motor doesn't work on the principle of electromagnetic induction.

Electric power plant : At an electric power plant, power (electricity) is generated by the rotation of a turbine in which blades are attached. In a hydro electric power plant to rotate the turbine water is continuously dropped on the blades of the turbine through storing water by constructing barrage. In a thermal power plant and in nuclear (atomic) power plant the turbines are rotated by vapour. In wind power plant turbine is rotated by the atmospheric pressure. In thermal power plant vapour is prepared by burning the coal or natural gas. But in atomic power plant the vapour is prepared by nuclear energy. Through the axis of turbine a coil or a core is attached which on the rotation of turbine (in a permanent magnetic field) starts to rotate and electricity begins to be generated.

At primary electric power plant alternating current (a.c.) is generated and it has alternating voltage of 22,000 volt or of beyond. This alternating current (a.c.) is sent to the consumers through the transmission line. At the grid sub-station step-up transformers are installed which can increase the alternating voltage up to 132000 volt. At this order of alternating voltage during the transmission less amount of electrical energy is lost. Ultimately at various sub-station this alternating voltage is decreased by step-down transformer and normally 220 volt (a.c.) is supplied to the domestic consumers.

Domestic power supply : The power is supplied for the domestic use of 220 volt (a.c.) which has the frequency of 50 Hz. This implies that its polarity in each second changes 100 times. Thus, in a complete cycle the alternating current (a.c.) changes its direction two times. Domestically supplied current is called main line, and the wire through which this current is passed out is called *mains*. Domestically supplied power has two types of current : one is of 5 ampere and other is of 15 ampere. The current of 5 ampere is called *domestic* and the current of 15 ampere is called *power line*. The current of 5 ampere is used in electrical appliances like electric bulbs, T.V., tube light, radio etc. But the current of 15 ampere is used in electrical appliances like electric heater, electric iron, refrigerator etc.

Domestic wiring : In domestically supplied current three types of wires are utilised which are live, neutral and connected to the earth (earthing). Ordinarily live wire is of red colour, neutral wire is of black colour and earthing wire is of green colour. Through the live wire electric current is passed, while through the neutral wire current goes back. In home usually two types of circuits are installed in which one circuit is for 5 ampere appliances and another for 15 ampere appliances. Earthing wire directly goes to the earth and it is a means or way of safety. In every circuit the electrical appliances are attached between the live wire and neutral wire. For the regulation of every appliance (equipment) there is a switch which is attached in every circuit from the live wire.

In home the distribution of power is made through an *electric meter*. The electric meter measures the power in kilo watt hour (kWh) which is expressed in unit. The power distribution through the *meter* is done by two pairs of wires grouped in parallel combination. In every pair of wires a *fuse* is attached. The fuses of all wires are attached at one place on the switch board. The home electrical appliances like fan, bulb, heater etc. are attached

with parallel combination of wires, while switches of these appliances are attached in the series combination of the wires.

Electric fuse : For the safety point of view electric fuses are utilised in various electrical circuits and thus electrical appliances are safeguarded. For the electric fuse those materials are used which have less melting point and easily melt on passing high electric current in the circuit. Whenever an overloading or a short circuiting occurs anywhere in the circuit, the current of a very large magnitude starts to flow in the wire and the wire of the electric fuse melts so that the concerned appliances are prevented to damage. Always electric fuse is attached through the live or hot wire. Normally electric fuse is made of tin but good quality of fuse is made from the alloy of copper, tin and lead. Usually the electrical circuit from where the current of 15 ampere is permissible to flow then thick wire is used for the fuse and through it maximum current passing capacity is of 15 ampere. Similarly for the electrical circuit from where the current of 5 ampere is permitted to pass a thin wire fuse is used and its maximum current passing capacity is of 5 ampere.

Socket : The socket is a three cylindrical holes fibre structure device from where three wires pass. In the socket, the uppermost hole is large from which earthing wire passes and from the lowermost right small hole live wire passes, while from the lowermost left small hole neutral wire passes.

Plug : In the plug there are three cylindrical needles which can be completely enclosed in the socket. When any plug fits directly with a socket then corresponding appliance is connected to mains (circuit) directly.

Regulator : The regulator acts (works) like a current controller in the electrical circuits. This is used normally to increase or decrease the speed of electric fan. Whenever the knob of the regulator is rotated then the electric resistance of the wire increases or decreases by which the quantity of electric current decreases or increases.

Electric switch : Through an electric switch the current in the circuit is either stopped or surpassed. With the electrical appliances like bulb, fan etc. switches are connected in series. While the switch is always connected between the phase wire and the appliance, but the neutral wire is directly connected to the appliance. Since the voltage of the phase wire is about 220 volt and during the off time or when appliances be not in action, phase wire must be detached from the appliances. If this is not to be done then appliance even in the absence of its action can provide a sharp electric shock to anybody who will touch the appliance. This detachment of the phase wire with the appliances are completed by installing the electric switches at suitable places in the electric circuits.

Important units of electricity : (A) Electrostatics

Physical quantity	**Units (SI)**	**Symbol**
Electric charge	Coulomb	C
Electric potential	Volt	V
Potential difference	Volt	V
Electric field intensity	Newton/coulomb	N/C
Electric capacity or capacitance	Farad	F

(B) Current electricity :

Physical quantity	Units (SI)	Symbol
Electric current	Ampere (amp)	A
Electric resistance	Ohm	Ω
Specific resistance or resistivity	Ohm Metre	Ω M
Electric conductivity	Ohm^{-1} or Mho or simen	Ω^{-1} S
Specific conductivity or Conductance	Ohm^{-1} Metre^{-1} or Mho Metre^{-1} or Simen Metre^{-1}	$\Omega^{-1}\ \text{M}^{-1}$ SM^{-1}
Electric power	Watt	W

Section–C Magnetism

About 600 century B.C. a natural substance (mineral) was found in Asia Miner which had the characteristic to attract its iron pieces. Such substance was called magnet and its characteristic (property) to attract was called magnetism. As magnetite occurs naturally, that's why it was called Natural magnet. The chemical composition of magnetite is Fe_3O_4 and it has no definite shape. If a magnet is suspended freely then it remains confined in North-South direction. Also it is observed that natural magnet has smaller power of attraction. Today artificial magnets are constructed which have a large power of attraction. The materials utilised for the magnet are iron, cobalt, nickel etc. and various shape of magnets like bar magnet, horse shoe-magnet, magnetic needle etc. are designed artificially.

Properties of magnet :

(i) Property of attraction : Pieces of iron, steel are easily attracted by a magnet and this power of attraction is found to be sharper near the ends of the bar magnet which are called poles of the magnet. In the middle of the magnet the power of attraction is very weak (feeble).

(ii) Property of directionality : If any magnet say a bar magnet is suspended freely, then the magnet remains confined in North-South direction. Here the end of the suspended magnet pointing towards North is called North pole and similarly to that South is called South pole. The imaginary straight line passing through both poles is called magnetic axis. The distance between both the poles is called magnetic length. If a freely suspended bar magnet is at rest, then the plane passing vertically upward from the magnetic axis is called magnetic meridian.

(iii) Property of attraction and repulsion of poles : Two unlike poles (North-South) attract each other while two like poles (South-North, South-South) repel each other. An isolated charge has its existence but an isolated pole of the magnet has no existence. If any magnet is broken then poles of the magnet do not become separate but a new magnet (broken part) is formed.

(iv) Property of magnetic induction : The magnetic induction is produced by the magnet in the magnetic substance. If a rod of soft iron is brought near the pole of a powerful magnet, then this rod also becomes a magnet. Also a pole of the opposite nature is induced in the rod of that pole of the powerful magnet. This is called magnetic induction.

Magnetic field : The region or space around a magnet through which any other magnetic material experiences a force of attraction or repulsion is called magnetic field. The direction of the magnetic field of any magnet is determined by a magnetic needle.

Magnetic field intensity or magnetic field induction : In any magnetic field if a charged conductor of unit length is kept transverse inside it and the electric current of unit ampere is passed through the conductor, then the force experienced by the conductor is called magnetic field intensity or magnetic field induction. If $\vec{F}$ be a magnetic force, $\vec{l}$ be the length of a conductor, i be an electric current and $\vec{B}$ be the magnetic field induction then

$$\vec{F} = i\,\vec{l} \times \vec{B} = ilB \sin\theta \; \hat{n}$$

Thus mathematically

if $i = 1$ amp

$l = 1$ metre

$\theta = 90^\circ$; then $F = B$

Obviously magnetic field intensity $\vec{B}$ is a vector quantity. C.G.S unit of $\vec{B}$ is *Gauss*. S.I. unit of $\vec{B}$ is N / amp-m or weber / metre^2 or Tesla.

Magnetic lines of force : There is a way of interpretation of magnetic field by drawing imaginary lines which are hypothetical field and it is simple indication of the direction of field and these lines are called magnetic lines of force.

The characteristic of the magnetic lines of force :

(i) The magnetic lines of force always originate from the North pole of the magnet and terminate at the South pole by tracing curve and return back from South pole to North pole internally.

(ii) Two magnetic lines of force never intersect each other.

(iii) At a stronger or sharper magnetic field the magnetic lines of force are closed to each other, while weaker (feeble) magnetic field is represented by magnetic lines of force far apart.

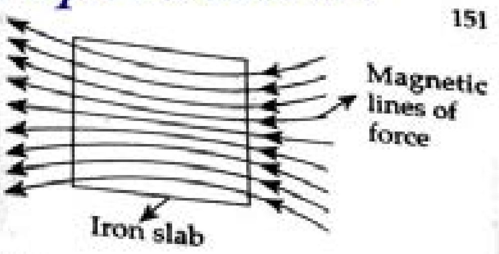
(iv) A uniform magnetic field is represented by equi-distant parallel lines drawn in the space.

Magnetic Permeability : If a magnetic substance say iron is kept, in any magnetic field then more and more magnetic lines of force cross through it in comparison to the air. In other words we can say that magnetic substance like iron, cobalt or nickle are good conductors of magnetic lines of force. This characteristic of the magnetic substance is called magnetic permeability.

As in the figure if an Iron slab is kept in a magnetic field then very sharp and concentrated magnetic lines of force appear to be confined within the slab, which is the representation of the permeability existence. The symbol of the permeability is μ and its value for air or vacuum is $4\pi \times 10^{-7}$ weber/amp-m.

If B is the magnetic lines of force through unit area of the magnetic substance and *H* is the magnetic lines of force through unit area in air, then permeability is defined as;

$$\text{Permeability } (\mu) = \frac{B}{H}$$



An another unit of the permeability is henry / metre

Magnetic susceptibility : It is observed experimentally that soft iron can be easily magnetised in comparison to steel, then it is said that susceptibility of soft iron is more than that of steel. But the soft iron piece loses its magnetism easily as compared to the steel. Thus, susceptibility of a substance (material) is defined in such a way in which a magnetic substance can be magnetised. But the retentivity of the soft iron is less as compared to the steel because the retaining power of the magnetism of soft iron is less as compared to the steel.

If the intensity of magnetisation developed in a material is *I*, then the

$$\text{Susceptibility} \quad (\chi) = \frac{\text{Intensity of magnetisation} (I)}{\text{Magnetising force} (H)}$$

Types of magnetic substances : Normally every substance in a strong magnetic field has some magnetic effect thus, broadly on the basis of magnetising behaviours it is categorised into three classes—

(i) Paramagnetic substance : The paramagnetic substances are those which, when kept in a strong magnetic field, become weakly magnetised in the same sense as the external field. Platinum, chromium, manganese, copper sulphate, liquid oxygen and solution of the salts of iron and nickel are examples of paramagnetic substances.

When a bar of paramagnetic substance is kept in an external magnetic field, then the flux density (field intensity) of it is slightly greater than the flux density in the free space. Thus, relative permeability $\mu_r (= \mu / \mu_0)$ becomes slightly greater than 1.

Characteristics

(a) If a bar of paramagnetic substance is suspended between the poles of a magnet, it shows poles at its ends which are opposite to those of the magnet and turns until it lies along the field.

(b) In a non-uniform field paramagnetic substances tend to move from a weaker to a stronger parts of the magnetic field. If a paramagnetic liquid is kept in a watch glass resting on two pole-pieces very near to each other, the liquid accumulates in the middle where the field is the strongest. If on other hand the pole-pieces are far apart, the field is the strongest near the poles and the liquid moves away from the centre producing a depression in the middle.

(c) When a paramagnetic gas is allowed to ascend between the pole-pieces of a magnet it spreads along the field.

(d) The susceptibility of a paramagnetic substance decreases with the rise in temperature.

(ii) Diamagnetic substance : The diamagnetic substances are those which become weakly magnetised in a direction opposite to that of the applied field. Bismuth, antimony, gold, water, alcohol, quartz, hydrogen etc. are the examples of such substances.

When a bar of diamagnetic substance is kept in an external field, flux density of it is less than the flux density of the free space. Thus, relative permeability μ_r for diamagnetics is less than 1.

Characteristic

(a) If a bar of diamagnetic substance is suspended between the poles of a magnet, it shows poles at its end which are similar to those of the magnet and turns until it is at right angle to the applied field.

(b) In a non-uniform field a diamagnetic substance tends to move from a stronger to a weaker parts of the field. If a diamagnetic liquid is kept in a watch glass resting on two pole-pieces very near to each other, the liquid is accumulated on the sides where the field is weaker, producing a depression in the middle. The reverse effect is observed when the poles are far apart.

(c) A diamagnetic field shows a depression in the limb of a U-tube kept between the pole-pieces of a magnet.

(d) When a diamagnetic gas is allowed to ascend in between the poles of a magnet across the field it spreads.

(e) The susceptibility of the diamagnetic substance is independent of temperature.

(iii) Ferromagnetic substance : The ferromagnetic substances are those which are strongly magnetised by a relatively weaker magnetic field and it has the same sense as the applied magnetic field. Iron, cobalt, nickel, godolinium and their alloys etc. are the most important ferromagnetics.

Ferromagnetics show all the characteristics of a paramagnetic to a much higher degree. The ferromagnetic substances have relative permeabilities of the order of the hundreds and thousands. The flux density in them may be hundreds and thousands times as great as that of the free space due to the same magnetising force. The flux density B in a ferromagnetic substance is not directly proportional to the magnetising force H. Thus the permeability $\mu\left(=\frac{B}{H}\right)$ is not constant.

The permeability (μ) of a ferromagnetic substance decreases with rise in temperature and becomes practically equal to μ_0 at a certain temperature, which is called *curie temperature*. Above the curie temperature the ferromagnetic substance becomes paramagnetic. The curie temperature for iron is about 770°C.

If a ferromagnetic substance is heated then its magnetic susceptibility (χ) is inversely proportional to the absolute temperature T, i.e. $\chi \propto 1/T$. Thus $\chi = C/T$ where C = a proportionality constant and T is called curie temperature and this relation is called curie's law. The value of the magnetic susceptibility (χ) decreases with the rise of temperature. At a point and at a particular temperature which is called curie's temperature a ferromagnetic substance is converted into a paramagnetic substance. The values of curie's temperatures for cobalt, nickel and iron are 373 K, 673 K and 1043 K.

Types of magnet : Normally the magnet is of two types :—

(I) Temporary Magnet : Temporary magnets are those in which magnetic substance magnetises easily and demagnetises quickly. That's why these magnets are also called electromagnets. Usually for constructing temporary magnet soft irons are used.

Electromagnets (temporary magnets) are used frequently in the electric alarm, in the core of transformer, in the dynamo in which soft irons are magnetised.

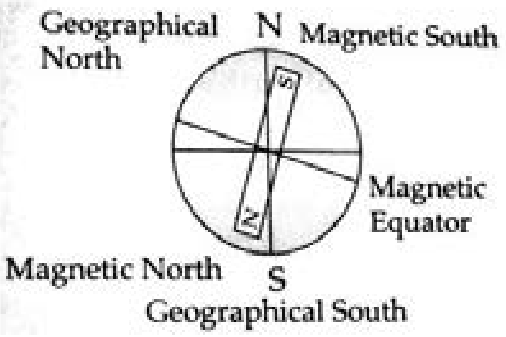
(II) Permanent Magnet : Permanent magnets are those in which magnetic substance magnetises by slowly and steadily in a long span of time and demagnetises also not easily. The stainless steel is frequently used for its construction and in order to obtain a good quality of permanent magnet.

In loudspeaker, needle indicator, Galvanometer etc. permanent magnets of the steel are used.

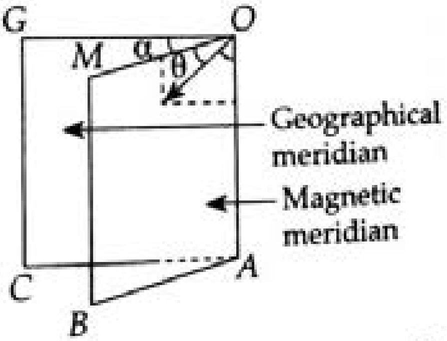
Domains : In ferromagnetic substance every atom of it behaves like a tini magnet and this substance has a large number of atoms in the group, which is called domain. In every domain about 10^{18} to 10^{21} atoms exist. Due to the collective contribution of these atoms a ferromagnetic substance has a sharp magnetism.

Terrestrial magnetism : When any magnetic compass (needle) is freely suspended through its centre of gravity (c.g.); then the compass remains confined in the North-South direction. Thus, magnetic compass to remain static in a particular direction tells us about the presence of magnetic field on the earth's surface. This is called terrestrial magnetism.

By the study of magnetic lines of force the behaviour and character of the earth appears like a great magnet, in which the magnetic North pole is oriented towards the geographical South pole and the magnetic South pole is oriented towards the geographical North pole.



If the magnetic needle is suspended freely through its *c.g.* and which is able to rotate in a vertical plane, then it doesn't remain horizontal but makes some angle with the horizontal.



Also if the freely suspended magnetic needle is taken away from North to South, then there are two places where the direction of the needle becomes vertical. Of these two places at one place the North pole of the vertical needle leans towards the earth is called magnetic North pole of the earth. At another place the south pole of the vertical needle also leans towards the earth is called magnetic South pole. If an imaginary straight line is drawn through the centre of the earth joining magnetic North pole and magnetic South pole of the earth, then this straight line is called magnetic axis of the earth. The angle between the magnetic axis with the geographical axis is of about 17°. Ultimately we can conclude that the magnetic and geographical poles are different and separate.

Here two terms become significant to understand the terrestrial magnetism in some more specific way.

Magnetic meridian : It is a vertical plane containing the direction of magnetic force at a place of a freely suspended magnetic needle. Thus plane *OABM* represents *magnetic meridian.*

Geographical meridian : It is a vertical plane through the geographical north and south direction at a place. Thus plane *OACG* represents geographical meridian in the figure.

At any place of the earth, the magnetic field of the earth depends on the three parameters called magnetic elements. These are—

(i) Angle of declination : At any place of the earth the angle between the geographical meridian and the magnetic meridian is called angle of declination. Obviously from the figure α is the angle of declination.

(ii) Angle of dip or angle of inclination : At any place of the earth the angle between the direction of the total earth's magnetic field intensity and the horizontal line in the magnetic meridian is called angle of dip or angle of inclination. Obviously from the figure θ is angle of dip. Also at the poles of the earth angle of dip is 90°, while at the equator the angle of dip is 0°.

(iii) Horizontal component of earth's magnetic field : The horizontal component of the entire magnetic field of the earth has different values at different places of the earth, but its average value at any particular place is assumed to be 0.4 Gauss or 0.4×10^{-4} Tesla.

Causes of earth's magnetic field : The cause of the earth's magnetism is still a vague (unsettled) question. So many theories regarding it were propounded time to time and over all contributions of all are relevant and significant only upto very small extent.

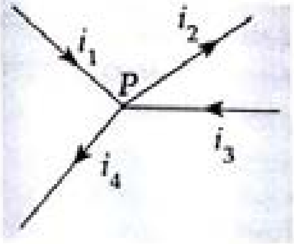
Gilbert in 1600 stated that the earth is a *great magnet,* but the experimental facts are not in the favour of this theory because the earth is not completely made up through the magnetic materials. Bond in 1676 suggested that the earth was surrounded by a magnetic sphere whose axis was inclined at 8°30′ to the axis of rotation of the earth. Similar theories were put forward by Halley and Hansteen. Gauss in 1839 came to conclusion that the magnetism of the earth is due to the materials within the earth. In 1849 Grover explained the earth's magnetism by assuming that it is due to an electric current circulating around the earth and this electric current is generated inside the earth due to the sun. The warm air ascends in the equatorial region, and moves towards the North and South in upper regions and get electrified. In 1870, Schuster came to a conclusion that the daily variation of the earth's magnetic elements is due to some external variations in the atmosphere.

Thus, the magnetic character of the earth cannot be explained clearly on any above ground and all the above logic and reasons may collectively make a mystrieous perception.

Miscellaneous :

1. Kirchoff's laws : Kirchoff in 1842 gave two laws which enable us to find out the distribution of current in any electrical network of conductors. In fact Kirchoff's laws are the consequences of two fundamental principles; the principle of conservation of charge and the principle of conservation of energy. These two laws are :

(i) In an electric circuit the algebraic sum of the currents meeting at any junction in the circuit is zero.



Thus, $\Sigma i = 0$

i.e. $i_1 - i_2 + i_3 - i_4 = 0$

where, Σ (sigma) = sum

i.e. $i_1 + i_3 = i_2 + i_4$

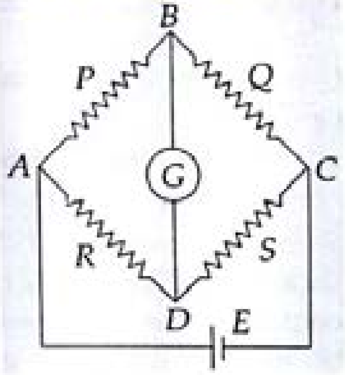
Thus the total current flowing toward a node (or junction) is equal to the total current flowing away from that junction. This is simply the charge conservation principle. When the currents in a circuit are steady, there can be no accumulation of charge at any point in the circuit.

(ii) In any closed loop (closed conducting path in the circuit) of a circuit, the algebraic sum of the products of the current and the resistance in each part of the loop is equal to the algebraic sum of *emf's* in that loop.

$\Sigma i R = \Sigma E$ where Σ (sigma) is the notation used for the sum.

Thus, it is simply a statement of the law of conservation of energy.

Application of Kirchoff's laws



Wheatstone bridge : Wheatstone bridge is an arrangement of four resistances *P, Q, S* and *R*, which are joined in a closed chain *ABCDA*.

A galvanometer of resistance G is connected across the diagonal *BD* and a cell *E* of *emf e* and internal resistance *r* is connected across *AC*. This whole arrangement is called a *Wheatstone bridge*.

Condition for a balance in Wheatstone bridge : A wheatstone bridge is said to be balanced, when no current through the galvanometer is passed out.

At the balance position $\frac{P}{Q} = \frac{R}{S}$

Usually the wheatstone bridge is used for a rapid and accurate measurement of resistance. The post office box (P.O. box) and the meter bridge are the practical applications of the wheatstone bridge.

2. Internal resistance of a cell : The resistance offered by the chemical solution between the electrodes of the cell is called *internal resistance* of the cell. It depends on the nature of the solution, and upon the current which is given to the cell. The car battery consists of an accumulator whose internal resistance is very small (about 0.01Ω) and resistance can not be measured by a wheatstone bridge, because of occurrence of insensitiveness. That's why we use meter bridge to measure such small resistance.

3. Some more devices (instruments)

(i) Van de graph generator : It is an instrument to produce a very high voltage (in million volts) and it is designed on the basic principle in which when a charged conductor is brought into the internal contact with a hollow conductor, then all of its charges transfer to the hollow conductor.

(ii) Cyclotron : A compact machine deviced by Lawrence and Livingston in 1932 to accelerate the positive ions like protons, deutrons and α-particles is called cyclotron (or cyclic accelerator). But by this machine (device) negatively charged particle (electron) cannot be accelerated because relativistic mass starts to increase abruptly with increase of velocity.

(iii) Betatron : The Betatron is a device through which a negatively charged particle (electron) is accelerated and gets sufficient energy even higher than the electrons (β-particles) emitted from a radioactive substance. The betatron-accelerated electrons can produce *X*-rays so short in wavelength and so penetrating in character as to surpass the gamma rays (γ-rays) from a radioactive substance.

(iv) Thermopile : It is one of the best known applications of the thermo-electric effect and it is a device through which small amount of thermal radiations are detected.

(v) Bolometer : The basic principle and function of the Bolometer is the same as that of a thermopile but it consists of a piece of resistance wire forming one arm of a bridge. When it receives energy its temperature rises, consequently its resistance rises and the balance of the bridge is disturbed. The current so flows through the galvanometer and a relation between this current and the rate of the absorption of energy is usually formed by calibration.

4. Some more terms related to the electrical circuits :

(i) Load : Load is a device or element which draws the current from a voltage source and thus the connection of a load reduces the voltage. A short circuit between two points has a direct connection and to shortout a component a thick wire is connected and is parallel with it. Load has an infinite resistance for an open circuit.

(ii) Impedance : The impedance is the quantity used in a.c. circuit and is similar to the ohmic resistance used in d.c. circuit and it is represented by Z.

(iii) Admittance : The reciprocal of the impedance in a.c. circuit is called admittance and it is represented by *Y*. Thus, admittance plays the same role in a.c. circuit as conductance plays in the d.c. circuit.

VI. Modern Physics (Atomic & Nuclear Physics)

Composition of matter : Since the primitive days it was assumed that every matter is the composition of small particles but there was no experimental evidence at that time regarding to it. In 1803 Dalton asserted and propounded that every matter around us is made of small particles and these are said to be atoms. Dalton also speculated that the atom is the basic constituent of all the matters and cannot be divided by any physical or chemical means. But later atom was also divided into electron, proton and neutron and these are called fundamental (elementary) particles. Of lately these are also assumed to be made from quarks. Some more micro particles also appeared along with the research and development activities of Atomic & Nuclear physics which have been kept in the class of elementary particles and at present there are nearly 30 elementary particles.

(i) Electron : Firstly invented fundamental particle is electron. In 1897 the electron was invented by J. J. Thomson. The electron is basically a negatively charged particle which rotates around the central massive part of the atom called nucleus and it is distributed in various energy levels and sub-levels of the atom.

The electron has a negative charge of 1.6×10^{-19} coulomb, while electronic mass (mass of the electron) is 9.1×10^{-31} kg. The electron is a stable fundamental particle.

(ii) Proton : The proton is another fundamental particle which was invented by Goldstein in 1919. It is basically a positively charged particle and it has a positive charge of 1.6×10^{-19} coulomb and the mass of the proton is 1.6×10^{-27} kg. The proton is confined to the nucleus of the atom. The proton is also another stable fundamental particle.

(iii) Neutron : This was invented in 1932 by James Chadwick. It is a neutral fundamental particle (no charge) confined to the nucleus. The mass of the neutron is approximately equal to that of the mass of the proton. Neutron is a unstable fundamental particle whose half life period is nearly of 17 minutes. It is utilised in life sciences and medical sciences frequently. Since it has no charge it is used in nuclear fission.

(iv) Positron : It is a fundamental particle which has the same mass, anti-spin as that of the electron and opposite charge of the electron. Thus positron is also called positive electron. Also positron was the first fundamental particle in the form of anti-particle of the electron which was discovered in 1932 by Anderson in a cloud chamber experiment exposed to the cosmic rays. When a positron comes to rest in matter, it is quickly annihilated by an electron resulting in two gamma photons (γ-photons)

$$\underset{\text{(positron)}}{e^+} \quad + \quad \underset{\text{(electron)}}{e^-} \quad \rightarrow \quad \underset{\text{(photon)}}{2\gamma}$$

(v) Neutrino : This fundamental particle was invented in 1930 by Pauli. This is a massless and chargeless fundamental particle. The antiparticle of the neutrino is called antineutrino which has anti-spin.

(vi) Pi-meson (π-meson) : It was invented in 1935 by H. Yukawa a Japanese physicist when he was propounding, Yukawa's meson theory of nuclear forces. The mechanism responsible for the strongly-attractive, non-electrical and non-gravitational, short-range nuclear forces between nucleons (protons + neutrons) remained a mystry for a long time. In this regard Yukawa predicted the existence of a new fundamental particle called pi-meson (π-meson) whose rest mass is about 230 times the rest mass of the electron (9.1×10^{-31} kg). He proposed a theory of nuclear forces which involves these π-mesons. According to this theory all nucleons (protons and neutrons) consists of identical cores surrounded by a *cloud* of one or more pi-mesons. The mesons may be neutral or may carry either a positive or a negative charge equal to the electronic charge and are designated as π^0, π^+ and π^- respectively. But π-meson is also a unstable fundamental particle whose average life time is 10^{-8} second.

(vii) Photon : The photon is a basic constituent of all the electromagnetic wave and has a discrete energy of $h\upsilon$ in each quanta and each photon moves with velocity of light whose rest mass is zero.

Miscellaneous :

Elementary particles : These are fundamental particles whose internal structure cannot be described as a combination of the other particles.

Anti-particles : Fermi-Dirac's relativistic quantum theory of electron predicted the existence of an anti-particle. The anti-particle of a given particle has exactly the same mass, spin and life time (if unstable) but of the opposite charge if any. Further, the alignment between the spin and magnetic moment of an anti-particle is opposite to that of the corresponding particle. Also when an anti-particle meets its particle, they mutually annihilate (destroy).

Electron-volt : The electron-volt is a unit of energy in Atomic physics (or particle physics) and it is expressed as below,

$$1 \text{ eV (electron-volt)} = 1.6 \times 10^{-19} \text{ Joule.}$$

Cosmic rays : Cosmic rays are highly penetrating radiations consisting of high energy atomic nuclei which are continuously coming from outer space. Every second about 10^{18} cosmic rays reach the earth's surface and they have a wide range of energy from 10^9 to 10^{18} electron-volts.

Elster and Geital in 1899 and Wilson in 1900 firstly detected the cosmic rays. They found that the charge on very well insulated electroscope always leaked away in time although there was no ionising agent nearby which could make the air conducting. It was then thought that the leakage of charge was due to the ionising radiation from the radioactive minerals in the earth. Victor Hess, in 1911 sent an electroscope in balloon and found that intensity of the unknown ionising radiation was larger at high altitudes of the surface of the earth. He therefore proposed that radiation has originated from somewhere outside the earth's atmosphere. The radiation was finally called *cosmic rays* by Milikan is 1925. Until a mystery has been sustained about the origin of the cosmic rays in the outer atmosphere.

Planck's Quantum theory : Planck in 1900 introduced a totally new idea to explain the distribution of energy among various wavelengths of the black body (cavity) radiation. He assumed that the atoms of the walls of the cavity radiator behave like oscillators, each with a characteristic frequency of oscillation. These oscillator emit electromagnetic radiant energy into the cavity and also absorb the same from it and maintain an equilibrium state.

Thus assumptions in this regard are —

(i) An atomic oscillator can have only descrete energies given as

$$E = n\,h\nu$$

where, ν = frequency of the oscillator.

h = a constant called Planck's constant.
n = an integer called quantum number.

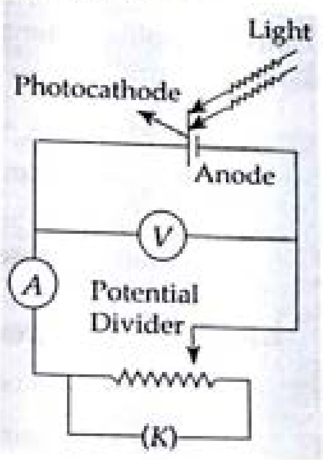
This implies that the oscillator can have only energies $h\nu$, $2h\nu$, ... and no energy between any of the two. Here the energy of the oscillator is said to be quantized.

(ii) The oscillators do not emit or absorb energy continuously but only in jump and in descrete way in the form of a packet of photon (quanta) and each packet carries an amount of energy $h\nu$.

So the energy of a single quanta (photon) = $E = h\nu = hc/\lambda$ ($\because$ $c = \nu\lambda$)

where, c = velocity of light in vacuum
λ = wavelength of the photon
h = Planck's constant = 6.625×10^{-34} joule-second.

Photoelectric effect



The emission of electrons from a metallic surface illuminated with light (photon) of appropriate wavelength or frequency is called photoelectric effect.

In other words photoelectric effect is a phenomenon in which, when the light (photon) of appropriate wavelength or frequency incidents on the metallic surface called photo cathode, then due to the production of photo electrons, photo current is generated. By the use of visible light, only certain alkali metals like sodium, potassium etc can exhibit the phenomenon of the photoelectric effect but using high frequency electromagnetic radiations (X-rays or γ-rays) almost metal can show the photoelectric effect. The photoelectric effect can also be exhibited by liquids and gases. But in liquid it is called electrolysis, while in the gas it is called ionization. It is also observed that the number of photoelectrons emitted per second (photo current) varies directly with the intensity of the incident light, but the energy (maximum) of the photo electrons is independent of the intensity of the incident light. The maximum energy of the liberated photo electrons only depends on the frequency of the incident light or its wavelength. Also this energy varies linearly with the frequency or inverse linearly with the wavelength of the incident light (photon)

Some terms related to photoelectric effect :

(i) Work function (ϕ) : The minimum energy of the incident photon required to liberate an electron from a metallic surface is called photoelectric work function (ϕ).

Thus for a photoelectric effect— Energy of radiation of photon ≥ work function (ϕ).

(ii) Threshold frequency (ν_0) : The minimum frequency of the incident radiation of the photon which is just sufficient to liberate an electron from the metallic surface is called threshold frequency (ν_0) for that metal.

Thus, threshold frequency is nothing new but the frequency of the work function.

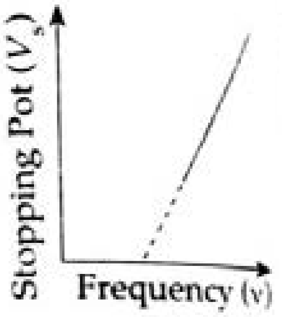
So for a photoelectric effect— frequency of radiation of photon ≥ threshold frequency (ν_0)

(iii) Threshold wavelength (λ_0) : The wavelength corresponding to the threshold frequency is called threshold wavelength (λ_0). It represents the longest wavelength above which the phenomenon of photoelectric effect is not possible.

Thus, for the occurrence of a photoelectric effect, the wavelength of radiation of photon ≤ threshold wavelength (λ_0).

(iv) Stopping potential (V_s) : That negative potential or voltage which just makes the photo current (through photo cell) zero or no photo electron emitted from the photo cathode be reached on the anode if anode be made more and more negative then the electrons are repelled. This potential is called stopping potential (V_0) and repelled electrons have the maximum kinetic energy.

Thus, this *K.E.* of a repelled electron is given by $\frac{1}{2} m v_{\max.}^2 = eV_s$



$\Rightarrow$ $v_{\max.}$ = maximum velocity of the repelled photo electron $= \sqrt{\frac{2eV_s}{m}}$

where; e = electronic charge (1.6×10^{-19} coulomb)

m = mass of the electron (9.1×10^{-31} kg.)

V_s = stopping potential

Einstein's theory of photoelectric effect : Before Einstein's theory various attempts were taken by the scientist to explain the phenomenon of photoelectric effect on the basis of the wave-theory. But the predicted time-lag between the light exposure and emission of electrons was not confirmed experimentally and so these explanations of wave theory were rejected.

After the failure of the wave-theory Einstein propounded his theory with the help of Planck's quantum theory.

He explained that when a photon of appropriate frequency (or wavelength) incidents on a metallic surface (photo cathode), then the energy of the corresponding photon is completely absorbed by the electron of the metallic surface in which the partial energy is utilised in ejecting the electron from the rest of surface and rest energy appears as kinetic energy of the photo electron.

Thus, Einstein's photo electric explanation is totally based upon the quantum theory and the phenomenon of photo electric effect cannot be explained by the wave-theory.

Mathematically,

Energy of incident photon ($h\nu$)

= work function (energy needed to eject the electron) + maximum *K.E.* of the electron

$$\Rightarrow h\nu = \phi + \frac{1}{2} m v_{\max.}^2 = h\nu_0 + \frac{1}{2} m v_{\max.}^2$$

$$\Rightarrow \frac{1}{2} m v^2_{\text{max.}} = h(\nu - \nu_0)$$

This equation is called Einstein's photoelectric equation.

where; ν_0 = threshold frequency
ν = frequency of incident photon
ϕ = work function
$= h\nu_0 = hc/\lambda_0$

Photoelectric cells : The device which converts light energy (photo energy) into electrical energy through the phenomenon of photoelectric effect is called photo electric cell or photo-cell. Depending upon different photoelectric effects employed, the photo cells are mainly of four types :

(i) Photo-emissive cells.
(ii) Photo-voltaic cells.
(iii) Photo-conductive cells.
(iv) Photo-multiplier tubes.

Applications of photoelectric cells :

(i) The photoelectric cells are frequently utilised in the reproduction of sound in the cinema and TV.

(ii) In the street light vapour lamps photoelectric cells are used which are automatically switched off during the day and switched on during the night.

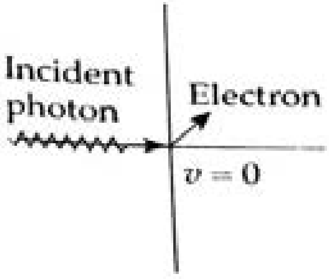
(iii) Automatic doors in the modern multiplexes and palatial complexes operate through the photo cells.

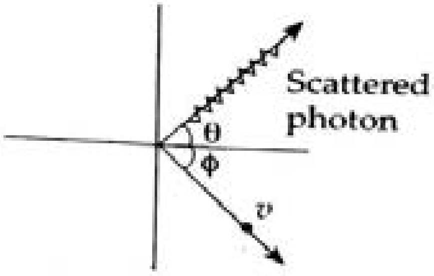
(iv) In the strong room of banking institutions the photo cells are installed to identify the unwanted person.

(v) In the space satellites photo cells are used which are charged in the day by solar energy, while at night the charged electricity is used up.

Compton effect : When a monochromatic (light or wave having same frequency and constant phase difference) beam of photon (say *X*-ray) is scattered by a substance, then the scattered *X*-rays have the radiation of not only the same wavelength as that of the original rays but also the radiation of longer wavelength. The former is called unmodified radiation and that of the later is called modified. The classical electromagnetic theory explained the unmodified radiation but it totally failed to explain the presence of the modified radiation.

Compton gave a satisfactory explanation on the basis of quantum theory for the modified radiation. Compton assumed that during the scattering process, the incident photon collides with a free electron (initially at rest) in the scattering material.





Incident photon transfers some of its energy to the electron which re with a velocity v in a direction making an angle ϕ with the direction of th incident photon. The photon itself with reduced energy is scattered in direction θ with the original direction. This scattered photon constitute th scattered modified radiation.

X-rays : X-rays are the short electromagnetic waves which are produc when rapidly moving electrons are stopped by the heavy metallic target lik tungsten, molybdenum, platinum etc. The metallic targets are made fro those which have high melting point, high atomic number and high therma conductivity.

X-rays were firstly observed and produced by Prof. W.C. Roentgen in 1895. X-rays were also referred to as Roentgen rays. Within three month after Roentgen's discovery, X-rays were being put to use in a hospital in Vienna in connection with major surgical operations.

The device through which X-rays are produced is called X-ray tube. There are two main types of the X-rays tube—

(i) Roentgen X-rays tube : This is also called gas filled X-rays tube designed by Roentgen himself. Roentgen X-ray tube is the oldest and the first-made tube.

(ii) Coolidge X-rays tube : Almost all the defects of Roentgen tube have been successfully removed in Coolidge-tube designed by W.D. Coolidge in 1913. At present practically all the X-rays tubes used for surgical works and others are of Coolidge type and that's why Coolidge X-rays tube is called modern X-rays tube.

Intensity and Quality of X-rays : The intensity of emitted X-rays is directly proportional to the number of electrons striking the target. This in turn depends upon the filament temperature, which can be controlled by the heating current. Thus by the variation of heating current, the intensity of X-rays beam can be controlled.

The quality or penetrating power of X-rays depends upon the energy of the electrons bombarding the target. This energy (eV) is determined by the applied potential difference (V) between the cathode and the target. The larger the applied voltage, the larger the energy of bombarding electrons and hence the larger the penetrating power of X-rays.

Origin of X-rays : X-rays are produced by bombarding high energy electrons on some heavy metals. Due to very large velocity, electrons penetrate well inside the atom of target metal and knock out one of the electrons of its innermost orbit like K, L- orbit. The vacant space is filled by the electron from the neighbouring outer shell and the balance of energy is emitted out as X-ray photon. Such X-rays are called characteristic X-rays, since these have discrete wavelengths depending on atomic number of the target atom.

X-rays are also produced due to a sudden stoppage (deceleration) of the electrons which give rise to continuous or white X-rays, whose wavelength varies from a certain minimum (λ minimum) to all possible values up to $\lambda = 250$ Å.

Properties :

(i) X-rays are electromagnetic waves of very short wavelengths from 0.1 Å to 250 Å. Thus, the wavelength of X-rays has the order of 1 Å.

(ii) X-rays having smaller wavelength up to about 10 Å are more energetic and it is called hard X-rays, while X-rays having larger wavelength above than 10 Å are less energetic and it is called soft X-rays.

(iii) X-rays photon is electrically neutral and travels with the speed of light (3×10^8 m/second), as no deflection takes place on passing through the electric and magnetic field.

(iv) X-rays exhibit wave and particle both aspect very prominently.

(v) The penetrating power of X-rays is very high so they can pass through many substances such as paper, cardboard, flesh, blood, leather, wood, metal sheet, concrete walls etc.

(vi) Although X-rays are strongly absorbed by the lead and bones, absorption of X-rays increases with increase in the thickness and the increase in the atomic number of atoms in the medium.

(vii) X-rays show optical phenomena like interference, diffraction, refraction and polarisation etc. very easily like the visible light.

(viii) X-rays are used in the research work and in the study of the structure of the crystals, arrangement of the atoms and molecules of the matter and their general behaviour.

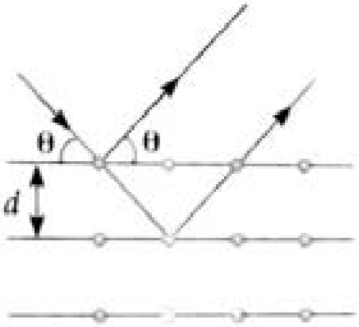
Moseley's law : It states that the frequency of the characteristic X-rays varies directly to the square of the atomic number of the element emitting it.

Thus frequency $(\nu) \propto (Z - b)^2$

i.e. $\nu = a\,(Z - b)^2$

where, Z is the atomic number and a, b are constants.

Bragg's law : A very specific study of X-rays diffraction from the crystals of the solid was done by British scientist team of father and son, Sir W. H. Bragg and Sir Lawrence Bragg. They pointed out that atoms of the crystalline solid are arranged in a regular pattern and that a set of equidistant planes can be drawn through the crystal. Such planes are called Bragg's planes and their separation as Bragg's spacing.



Bragg's law explains the condition for X-rays reflected by the crystals to cause constructive interference.

Applying the usual condition for constructive interference Bragg obtained the relation;

$2d \sin\theta = n\lambda$; where

d = separation between two consecutive planes.

λ = wavelength of X-rays beam.

θ = glancing angle.

n = order of interference maxima.

During the X–rays production nearly 99.8% energy of the incident beam of the electrons on the target is converted into the heat which is given to the metallic target, and only 0.2% energy appears as X-rays. Roentgen is the unit of X-ray dose.

de-Broglie hypothesis of matter waves : The wave theory of light successfully explained the phenomena like interference, diffraction etc, but failed to explain the phenomena like photo electric effect, compton effect etc. These phenomena although explained on the basis of Planck's quantum theory. According to the quantum theory a beam of light of frequency v is composed through the tiny discrete packets called *photons*, each having an energy hv, where h is Planck's constant. Thus, light possesses a dual character, behaving as a wave as well a particle (photon).

Similar to the dual character of light, de-Broglie in 1924 introduced the hypothesis that all the material particles in motion possess a wave character also. According to de-Broglie micro subatomic particles like electron, proton, neutron etc. can be associated or interpreted as waves. These waves are called matter waves or de-Broglie waves.

de-Broglie wavelength of matter waves is expressed as $\lambda = \frac{h}{p}$

where, h = Planck's constant

p = momentum of the photon

If an electron is accelerated through a $p.d\ V$ from rest, then velocity aquired by the electron say, v (non-relativistically)

$$\Rightarrow \quad \frac{1}{2} m_0 v^2 = eV \ ; m_0 = \text{rest mass of the electron}$$

$$\text{i.e.} \quad v = \sqrt{\frac{2eV}{m_0}}$$

But de-Broglie wavelength, $\lambda = \frac{h}{p} = \frac{h}{mv} = \frac{h}{m_0 v}$

$$\text{Thus } \lambda = \frac{h}{m_0\sqrt{\frac{2eV}{m_0}}} = \frac{h}{\sqrt{2m_0 eV}}$$

$$= \frac{6.625 \times 10^{-34}}{\sqrt{2 \times 9.1 \times 10^{-31} \times 1.6 \times 10^{-19} \times V}}$$

$$= \frac{12.27}{\sqrt{V}} \text{ Å} \simeq \sqrt{\frac{150}{V}} \text{ Å}$$

The Davisson-Germer experiment gave the direct verification of de-Broglie hypothesis of the wave nature of the moving particles.

Heisenberg's uncertainty principle : This principle was described by Heisenberg in 1927 and it states that we can measure either the position or the momentum of a particle with any desired degree of accuracy (within the limits of experimental equipment) but it is impossible to measure both the position and momentum simultaneously with unlimited accuracy.

Heisenberg said that if we design even an ideal experimental device to measure simultaneously the position x and the corresponding component of momentum p_x of a particle, there will be an uncertainty of Δx in the position and an uncertainty of Δp_x in the momentum such that $\Delta x \Delta p_x \geq h/4\pi$ where h = Planck's constant.

Thus, uncertainty principle states :

The product of the uncertainty Δx in the position of a body at some instant and the uncertainty Δp_x in its component of momentum at the same instant is equal to or greater than $h/4\pi$.

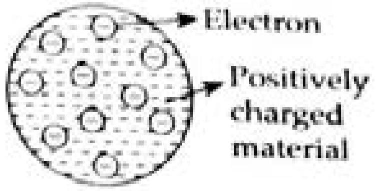
If one quantity is tried to be measured exactly, then other will become completely uncertain and vice-versa.

Atomic models : Matter despite its appearance of being continuous, possesses a definite particle structure on a microscopic level and the ultimate particles of matter are called atoms. Today an atom is assumed to be constituted through electrons, protons and neutrons.

The first information about the structure of atom came from the discovery (invention) of electron in 1897, when it became known that all atoms contain the negatively charged electrons. Since matter is electrically neutral, it was inferred that atoms must also contain positively charged material. Also an electron was found to be thousands of times lighter than the entire atom. This implies that the positive charge of an atom carries nearly the entire mass. The radius of the atom was estimated to be of the order of 10^{-10} meter from the kinetic theory of matter.

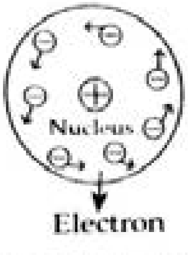
Thus, to know the entire aspect of the atom, various models were propounded as given below :

(i) Thomson's atomic model : Thomson in 1904 suggested that an atom is a uniform sphere of a positively charged material in which electrons are embeded in such number as to balance and neutralize the positive charges. The model though was soon discarded as it was in complete disagreement with experiments on the large-angle scattering of α-particles by the matter.



(ii) Rutherford's atomic model : Rutherford suggested that in an atom the entire positive charge and nearly all of its mass are concentrated at the centre of the atom in a small volume known as the nucleus of the atom. The electrons revolve around the nucleus in the planetary orbits at a larger distance compared with the size of the nucleus. The orbital motion was assumed because without it the electrons will fall into the nucleus under the electrostatic attraction and the atom will collapse.

This model was in fact based upon the results of α-particles scattering experiment. Most of the α-particles falling upon the metallic foil go through the atoms practically undeviated because the atoms are largely hollow and the electrons due to their little mass do not appreciably affect the motion of the incident α-particles. Those particles which pass close to the (positively charged) nucleus however experience strong electrostatic repulsion and are scattered through a large angle.



But Rutherford's model despite the strong experimental support, faced certain difficulties. The revolving electrons are constantly accelerated (centripetal) towards the nucleus. Such electrons according to classical electromagnetic theory will constantly radiate energy in the form of electromagnetic waves. Hence the electrons will be rapidly spiralled out and will fall into the nucleus and the atom will collapse. But in practice, atom doesn't collapse. Also in Rutherford's model the electron can revolve in orbits of all possible radii and so they should emit continuous radiations of all the frequencies. But the experimental fact is that atoms like hydrogen emit line spectra of radiation of only certain fixed frequencies in discrete form. Thus this model was also discarded.

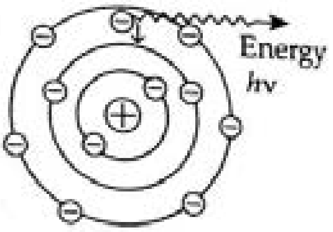
(iii) Bohr's (Quantum) atomic model : In 1913, Niels Bohr gave a new and bold idea of atomic structure in order to explain the stability of the atom and the emission of sharp spectral lines. He proposed the following two modifications in Rutherford's model which were contrary to the classical electromagnetic theory.

(a) The electrons can revolve around the nucleus only in certain fixed orbits and they do not radiate energy while they remain in these permitted orbits, and the atom is stable. The permitted orbits are those in which angular momentum of the electron is quantized and this angular momentum (mvr) of the electron is an integral multiple of $\frac{h}{2\pi}$

Thus, $mvr = \frac{nh}{2\pi}$. where n = quantum number

h = Planck's constant

(b) The emission (or absorption) of the radiation by the atom takes place when an electron jumps from one quantized (permitted) orbit to another. The radiation is emitted (or absorbed) as a single photon (quantum) whose energy $h\nu$ is equal to the difference in energy ΔE of the electron in the two orbits involved.



Thus, $\Delta E = h\nu$,

where, ν = frequency of emitted or absorbed radiation

Hence, the spectrum of the atom will have certain fixed frequencies.

The main objection against the Bohr's model was that its assumptions were entirely arbitrary and could only be justified by the experimental results.

Bohr's atomic model is the first model which was accepted but due to lack of explaining the intensity of the spectral lines, fine structure of spectral lines, spectra of complex atom etc. a new atomic model which was called Vector model was developed and in it everything were explained which were lacked in the Bohr's model.

Zeeman Effect : Zeeman in 1896 observed that when a light source providing line spectrum is kept in an external magnetic field, the spectral lines emitted by the atoms of the source are split into a number of polarised components. This effect of magnetic field on the atomic spectral lines is called Zeeman effect.

Raman Effect : When a strong beam of visible or ultraviolet line-spectral light illuminates a gas, a liquid or a transparent solid, then a small fraction of the light is scattered in all directions. The spectrum of the scattered light is found to have the lines of the same frequencies as the incident beam (called Rayliegh lines) and also certain weak lines of the changed frequencies. This production of additional new lines is called Raman effect, and lines are called Raman lines. The Raman lines corresponding to each exciting (Rayliegh) line occur symmetrically on both sides of the exciting line. The lines on the low-frequency side of the exciting line are called stokes lines, while those on the high-frequency side are called anti-stokes lines. The anti-stokes Raman lines are much weaker than stokes Raman lines.

The displacement (in cm^{-1}) of the lines are independent of the frequencies of the later. If an another light source with a different line-spectrum is used, then another Raman lines are obtained for the same scattering substance. However, the displacements from the exciting lines are the same. For different scattering substances, the displacements have different magnitudes. Thus, the Raman displacements are the characteristic of the scattering substance.

Pauli's exclusion principle : The electrons in an atom are distributed in a definite way among various shells and sub-shells. This distribution is governed by a principle given by Pauli in 1925. This is called *Pauli's exclusion principle.* This states that no two electrons in an atom can exist in the same quantum state. This concludes that no two electrons can have the same set of the four quantum numbers. There are certain numbers whose specification actually explains in detail configuration of the electrons in the shell and sub-shell which are called quantum numbers. There are four quantum numbers - principal quantum number (n). Orbital or azimuthal quantum number (l), spin quantum number (s) and magnetic quantum number (m_l).

Radioactivity : Radioactivity is in fact a chance discovery by Henry Becquerel, a French scientist. In 1896 he found that a photographic plate wrapped around three folds in the black paper was affected by a piece of mineral uranium kept over it for some time. Some rays were thought to be emitted by the uranium piece which could pass through the black paper and subsequently affected the plate. Intensive research work were carried out by Becquerel, Madam Curie and Pierre Curie which confirmed that this type of radiation was not only limited to uranium but a number of other elements like thorium, radium, polonium etc. and their salts also emit similar penetrating radiations. Such elements are said to be radioactive and the spontaneous emission of the radiation is called radioactivity (natural). Such spontaneous invisible radiations also penetrate through the opaque substances which ionise the gases and affects the photographic plates.

The property associated with the emission of this types of penetrating radiations are called radioactive rays or Becquerel rays (α, β and γ-rays). Soddy was the first to suggest that this type of radiation is a result of the transformation of a unstable nucleus to a more stable nucleus. Rutherford studied the effect of electric and magnetic fields on the radiation emitted by different radioactive substances. He observed that the radiation has three

(ii) The emission occurs spontaneously and cannot be speeded up or slowed down by the physical means such as change of pressure, temperature etc.

(iii) The disintegration occurs at random and which atom would disintegrate first is simply just a matter of chance.

(iv) The rate of disintegration of a particular substance (i.e. number of atoms disintegrating per second) at any instant is proportional to the number of atoms present at that instant.

If N be the number of atoms present in a radioactive substance at any instant t, and dN be the number that disintegrates in a short interval dt. Then the rate of disintegration is $-\frac{dN}{dt}$ which is proportional to N i.e.

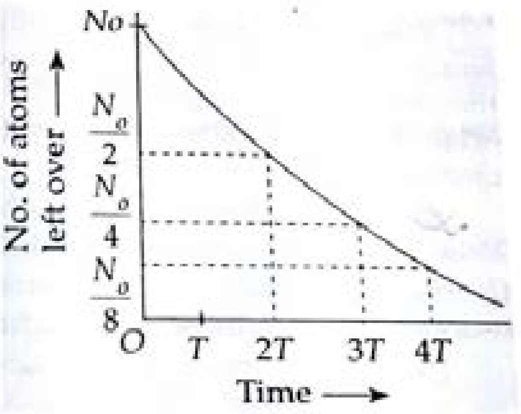
$-\frac{dN}{dt} = \lambda N$. where; λ is called decay constant. (–ve sign indicates that atoms decay with time).

$$\Rightarrow \quad \frac{dN}{N} = -\lambda \, dt.$$

On integration and simplification, $N = N_o e^{-\lambda t}$

where, N_0 = number of atoms in the begining.

N = number of atoms at the time t.



This equation shows that the number of atoms of a given radioactive substance decreases exponentially with time (i.e. more rapidly at first and slowly afterwards). This is called Rutherford-Soddy law of the radioactive decay.

Half life period : The atoms of a radioactive substance undergo continuous decay so that their number goes on decreasing. The time-interval T in which the mass of a radioactive substance or the number of its atoms is reduced to half its initial value is called the half-life period of that substance.

The half life period of a radioactive substance is constant, but it is different for different substances.

As by Rutherford-Soddy law;

$$N = N_0 \, e^{-\lambda t}$$

where, λ is the decay constant.

Now, let T be the half life period of any substance then $N = \frac{N_0}{2}$

$$\text{Thus} \quad \frac{N_0}{2} = N_0 \, e^{-\lambda t}$$

$$\Rightarrow \quad \lambda T = \log_e 2 \quad (\because t = T)$$

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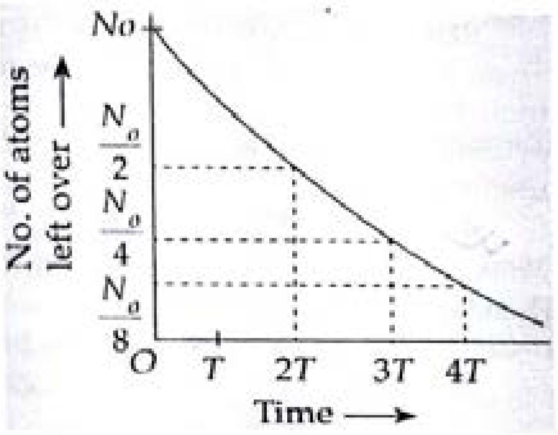

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$$_{Z}X^{A} \rightarrow {}_{Z+1}Y^{A} + \beta + \overline{\upsilon}.$$

Thus, (parent nucles) (daughter nucleus)

Similarly, $_{6}C^{14} \rightarrow {}_{7}N^{14} + \beta + \overline{\upsilon}.$

$_{90}Th^{234} \rightarrow {}_{91}Pa^{234} + \beta + \overline{\upsilon}.$

Nuclei having excess neutrons (high value of n/p ratio) are found to decay by β-emission.

(iii) γ-decay : When a parent atom emits gamma rays, no charge is involved as these are neutral rays, so no change in mass number and atomic number during γ-decay takes place. In fact γ-rays are electromagnetic waves having energy in the form of photon and its emission changes the nucleus from an excited state (high energy state) to a less excited (lower energy state) state.

The above mechanism of radioactive transformations (α, β and γ-decays) are called *Soddy-Fajan's group displacement laws.*

Radioactive series : Practically all the natural radioactive elements lie in the range of atomic numbers from $Z = 83$ to $Z = 92$. The nuclei of these elements are unstable and disintegrate by ejecting either an α-particle or a β-particle. By ejection of α, β-particles new atoms are formed and if these atoms have also unstable nuclei then further emission also takes place, until a stable nuclei is not to be found and a series of radioactive elements are obtained called radioactive series.

There are four radioactive series (UTAN)—

(i) Uranium Series : In this series the parent element is uranium-$_{92}U^{238}$ and the end product of this series after the the emission of six α-particles and five β-particles is obtained as radium lead ($_{82}Pb^{206}$) which is indistinguishable chemically from the ordinary lead and it is a stable isotope of the lead.

(ii) Thorium Series : The parent element of this series is Thorium - $_{90}Th^{232}$. It goes through a series of transformations in many respects similar to the uranium series and ends with a stable isotope of lead ($_{82}Pb^{208}$).

(iii) Actinium Series : The parent element of this series is an isotope of Uranium called Actino-Uranium-$_{92}U^{235}$ and its end product is again a stable isotope of lead ($_{82}Pb^{207}$).

(iv) Neptunium Series : With the discovery of the unstable transuranic elements (the elements of atomic number greater than 92 are called transurenic elements), another radioactive series was traced out. This is called Neptunium series after its longest-lived member Neptunium. Its origin is traced back to plutonium and it doesn't end in a stable isotope of lead but in the stable isotope of Bismuth ($_{83}Bi^{209}$).

Activity of radioactive substance and its units : The activity of a sample of any radioactive material is the rate at which its constituent atoms disintegrate. Thus if dN be the number of atoms which disintegrate during a time-interval dt, the activity of the sample will be given by

$$\text{activity} = -\frac{dN}{\quad}$$

The negative sign indicates that the number of atoms is decreasing with time.

The traditional unit of the activity is curie and 1 curie (C*i*) = 3.7×10^{10} disintegrations/second.

An another unit of the activity is Rutherford and 1 Rutherford = 10^{6} disintegrations/second.

SI unit of the activity is the becquerel (Bq) and 1 becquerel (Bq) = 1 disintegration/second.

Thus 1 Ci = 3.7×10^{10} Bq.

Artificial radioactivity : The idea of artificial radioactivity was firstly conceived by I. Curie and F. Juliot. Hence I. Curi & F. Juliot were assumed to be the real inventor of artificial radioactivity. The radioactive elements in which natural disintegration of nucleus occurs are heavier elements. Rutherford took the attempt and became successful in making a stable nucleus of ordinary nitrogen by the bombardment of fast moving α-particles. This phenomenon of making a stable nucleus into an unstable nucleus by the artificial means is called artificial radioactivity or induced radioactivity or man-made radioactivity.

Thus, when a nitrogen nucleus (${}_7N^{14}$) is struck by an α-particle (${}_2He^4$), a proton (${}_1H^1$) is ejected leaving the recoiling oxygen nucleus (${}_8O^{17}$).

$$\underset{\text{Nitrogen}}{{}_7N^{14}} + \underset{\alpha\text{-particle}}{{}_2He^4} \rightarrow \underset{\text{Oxygen isotope}}{{}_8O^{17}} + \underset{\text{proton}}{{}_1H^1}$$

Rutherford thereby transformed ordinary nitrogen into a rare isotope of oxygen. This was the first artificial nuclear transformation.

Carbon dating : The idea of the carbon dating was suggested by Prof. Libby, an Atomic scientist of Chicago. Our atmosphere contains a large number of stable isotopes. When cosmic rays strike these isotopes, a number of radio isotopes are produced. One of these radio isotopes is carbon-14 (${}_6C^{14}$) which is produced by the bombardment of atmospheric nitrogen with high energy neutrons.

$${}_7N^{14} + {}_0n^1 \rightarrow {}_6C^{14} + {}_1H^1.$$

Radio carbon is unstable and decays (by emitting β-particle) to nitrogen with half life of 5600 years. The carbon-14 is incorporated into the atmospheric carbon dioxide molecules which are taken inside by the plants when they breathe CO_2. Animals which eat the plants also take carbon–14 inside theirself. Ultimately the concentration of ${}_6C^{14}$ in all living organisms reaches at an equilibrium value of nearly 15 decays/minute. When an organism dies, it stops taking ${}_6C^{14}$ from the atmosphere and the concentration of ${}_6C^{14}$ present in organism decreases with the time. By measuring the ratio of the concentration of ${}_6C^{14}$ to ${}_6C^{12}$ in any ancient organism, say tree one can estimate the real date and time when the organism was died ?

Nuclear sizes and shapes : The Rutherford α-particle scattering experiment established that the mass of an atom is concentrated within a small positively-charged region at the centre which is called *nucleus* of the atom. Since during Rutherford's time many scattering experiments, using highly energetic electrons and neutrons as the scattering particles, have been performed to determine the size of the nucleus. An electron interacts with a nucleus only through the electrical forces, while a neutron interacts only through the nuclear forces. Thus, the electron scattering tells us about the distribution of the charge in a nucleus and neutron scattering tells us about the distribution of the nuclear mass. These experiments have shown that the volume of a nucleus is directly proportional to the number of nucleons present in it, which is its mass number A.

If the nuclear radius of any nucleus be R then the volume will be $4/3\pi R^3$ and so R^3 will be proportional to A.

Thus, $R = R_0\, A^{\frac{1}{3}}$.

The value of the constant R_0 is experimentally found which is given by $R_0 = 1.2 \times 10^{-15}$ m

Here, the length 10^{-15} m is described as 1 femtometer (fm) or 1 fermi.

So $R = R_0\, A^{\frac{1}{3}} = 1.2\, A^{\frac{1}{3}}\, fm$, for the all nuclear radii. The radius varies from nucleus to nucleus but their order is of 10^{-15} meter or 1 fm. For most purposes atomic nuclei are assumed to be spherical.

Packing fraction : The masses of the all atomic isotopes are very close to the whole numbers, but not exactly the whole numbers. The difference between the actual atomic mass M of an isotope and its mass number is defined as the packing fraction P of the isotope.

Thus, $P = \dfrac{M - A}{A}$

The packing fraction is positive for the isotopes of very low and very high mass numbers and negative for the rest. It is zero for ${}_6C^{12}$.

Mass defect and Binding energy : The masses of all the stable nuclei are less than the sum of the masses of their constituent particles (protons and neutrons) in the free state. This means that when the protons and neutrons combine to form a nucleus, a loss of mass results. The missing mass is released in the form of energy when the nucleus is formed.

If Δm be the missing mass in the formation of a nucleus, the energy released ΔE will be given by Einstein's mass energy equivalent relation;

$$\Delta E = \Delta mc^2.$$

where, c is the speed of light.

The missing mass (Δm) is called the mass defect and its energy equivalent (ΔE) is called binding energy of the nucleus. Here ΔE would is the actual energy that must be supplied to the nucleus to break into its constituent particles. More binding energy means the energy required to break the nucleus is larger. Thus binding energy is a measuring parameter of the stability of the nucleus.

Practical units for mass energy equivalence : In nuclear physics, the mass of the fundamental (elementary) particles is generally expressed in terms of unified mass unit (u), defined as one twelfth (1/12th) of the mass of the normal carbon atom (${}_6C^{12}$).

Also $1\ u = 1.67 \times 10^{-27}$ kg.

The energy of a particle/wave is expressed in terms of electron-volt (eV), which is the energy acquired by an electron in falling through a potential difference of one volt.

Also, 1 eV = 1.6×10^{-19} joule.

The equivalent energy for 1 unified mass unit is expressed as

$$1\,u \approx 931 \text{ MeV} = 931.5 \text{ MeV. (exactly)}$$

Nuclear fission : In 1939 two German scientists Otto Hahn and Fritz Strassman discovered a new type of nuclear reaction. They found that when any uranium nucleus ($_{92}U^{235}$) is bombarded with a neutron then, the nucleus splits up into almost equal fragments with the release of some free neutrons and tremendous amount of energy (about 200 MeV) per $_{92}U^{235}$ nuclei. Such a nuclear reaction is called nuclear fission.

Thus, the process in which a heavy nucleus splits up into the two nuclei of nearly comparable masses with a tremendous release of energy and some free neutrons is called nuclear fission.

One of the typical fission reaction is—

$$_{92}U^{235} + {}_0n^1 \rightarrow ({}_{92}U^{236}) \rightarrow {}_{56}Ba^{144} + {}_{36}Kr^{89} + 3\,{}_0n^1 + \Delta E \text{ (200 MeV)}$$

In the fission process of $_{92}U^{235}$ slow neutrons take part and their products are not always barium and krypton, so many possible pairs of the fragments occur. The average number of neutrons which are released in the uranium fission is 2.5.

Nuclear chain reaction : As 2.5 neutrons are produced per fission through each uranium atom and these neutrons produced in the nuclear fission under the favourable condition cause further atoms of uranium to undergo fission and in turn emit more neutrons which will cause further fission explosion. Thus, a chain reaction is established in a short span of time releasing an enormous amount of energy. One gram of $_{92}U^{235}$ on fission releases nearly 2×10^7 kilo calorie of energy.

The ratio of the rate of production of neutrons to the rate of their disappearance is called the reproduction factor (k). If k is less than 1, the chain reaction will not be sustained, at $k = 1$, the reaction will just be sustained and if k is greater than 1, the reaction will sustain.

Types of nuclear fission : The fission chain reaction is of two types namely;

(a) Controlled chain reaction : A fission chain reaction which proceeds slowly and in balanced manner without any explosion and in which the energy released can be controlled is called controlled chain reaction.

Nuclear reactors operate on this principle, which are the main sources of the nuclear power and in which controlled nuclear chain reaction takes place. In a nuclear reactor the energy released through the fission is used to generate electricity. Several nuclear power plants for the generation of electricity are operating in India and in various countries of the world.

Basic components of the nuclear reactor :

(i) Nuclear fuel : The elements undergoing fission in a reactor are called nuclear fuel. Some common fuels are uranium isotopes U^{233}, U^{235}, thorium isotope Th^{232} and plutonium isotope Pu^{239}.

(ii) Moderator : Moderators are used to slow down the emitted neutrons which have a high velocity range. Some common moderators are graphite, heavy water, beryllium, beryllium oxide and some organic liquids. Slowing down of neutrons is also called thermalisation of the neutrons. Heavy water (D_2O) is one of the best moderator.

(iii) Coolant : A coolant removes the tremendous amount of heat developed inside the reactor core. Through a heat exchanger, the coolant transfers heat to the secondary thermal system of the reactor. Water, steam, helium, CO_2, air, molten metals etc. are used as coolants.

(iv) Control rods : The control rods are used in initiating and stopping the nuclear fission reactions of the nuclear reactor. Due to large absorption cross-section area, cadmium and boron rods are used as control rods. When control rods are inserted in the reactor unit, they absorb the fast moving neutrons and the chain reaction ceases.

(v) Radiation protective arrangement : In a nuclear reactor large amount of penetrating radiations like γ-rays in addition to the neutrons are also generated. These radiations pose a danger to the technicians working around the reactor. Hence a reactor is always surrounded by a thick shield in the form of concrete wall many meters thick (lined with lead) to absorb these radiations and prevent them from the leakage to the adjacent areas.

Types of fission reactors :

(i) Homogenous and Heterogeneous reactors : Basically both are fission reactors but in homogeneous type, fuel and moderator are mixed to form a mixture, while in heterogeneous type fuel and moderator are separately carried out in the steel tubes.

(ii) Fast breeder reactors : A nuclear reactor that breeds (produces) more fissile material than it consumes is called breeder reactor. These reactors are much more economical than other type of reactors as they consume raw fuel like Th^{232} and U^{238}. ${}_{90}Th^{232}$ is not fissionable but through a fast breeder reactor it is converted to U^{233} which is a very good nuclear fuel. Similarly U^{238} is converted to Pu^{239} (Plutonium) which is very useful fissionable material. Owing to a very high temperature about 9000°C in the core, a molten metal is used as coolant.

(b) Uncontrolled or Explosive chain reaction : A nuclear chain reaction in which fission neutrons keep on increasing until the whole of the fissionable material is consumed is known as explosive or uncontrolled chain reaction.

Such a reaction proceeds very quickly with the liberation of huge amount of energy in a short time. An atom bomb works on this principle and it is a practical example of the uncontrolled / explosive fission.

Nuclear Fusion : When two or more light nuclei moving with high speeds are fused together to form a single nucleus, then this process is called nuclear fusion. The mass of the product nucleus is less than the of the masses of the nuclei which are fused. The lost mass is converted in energy which is released in the form of fusion energy.

The energy output in a fusion reaction is 24.6 MeV which is too muc less than energy released in the fission of a U^{235} nucleus which is about 2 MeV. But this doesn't mean that the fusion is a weaker energy source than the fission. The number of deutrons (reactants of the fusion reaction) in 1 g of heavy hydrogen is much larger than the number of U^{235} nuclei in 1 gm of uranium. Thus, the energy output per unit mass of the material consumed is much more in the case of fusion of the light nuclei than in the case of the fission of heavy nuclei.

The process responsible for the solar energy is the fusion of light nuclei and here four hydrogen nuclei fuse together directly to form a helium nucleus.

$$4\,{}_1H^1 \rightarrow {}_2He^4 + 2\,{}_{+1}\beta^0 + 2\nu + \Delta E \text{ (24.6 MeV)}$$

The fusion process is very difficult to carry out, as the nuclei to be fused are positively charged, so they will repel one another strongly. Hence they must be brought very close together not only by the high pressure but also with high kinetic energies of about 0.1 MeV and for it a temperature of the order of 10^8 kelvin is required. Such high temperatures are available on the sun and stars. On earth fusion may be produced by exploding a nuclear fission bomb. Thus, a very high temperature is needed for the fusion of nuclei, the process is called a thermo nuclear reaction and the corresponding energy as *thermo nuclear energy*. Also at the temperature of 10^8K fusion materials (hydrogen, deutron, tritum etc) become ionised and the electrons are stripped and alongwith the nuclei, these materials behave like an ionised gas which is called *plasma* (fourth state of matter).

Plasma confinement and control fusion : There is no material container which can accumulate plasma within itself, but if an alternating magnetic field of a very large magnitude generated by mega ampere current and if a torus-shaped machine is used, then plasma can be confined. The torus-shaped machine, developed firstly by former USSR is called tokamak. Such alternating magnetic field repels the plasma from the side and compels it to remain confined to the centre of the container (vessel).

By such methodology and some other alternative ways, the path of development towards the formation of nuclear fusion reactors was searched. The nuclear fuel of the fusion reactors is heavy water (D_2O) which is found abundantly in the oceans or seas. Thus, the acute power crisis could be easily sorted out if the fusion reactors become operative. The research and development activities are going on in this regard and a prototype of nuclear fusion reactor has perhaps been designed and fabricated by France but it is yet to be confirmed.

Uncontrolled/Explosive fusion : Hydrogen bomb works on the principle of nuclear fusion and it is approximately 1000 times more powerful than atom bomb (fission bomb). The essential conditions for the operation of a hydrogen bomb or the start of nuclear fusion, an extremely high temperature and pressure is required. Thus for the achievement of the essential conditions the functioning of a hydrogen bomb, an atom bomb (fission bomb) is used as a primer. The hydrogen bomb has no limitation like atom bomb and it will never explode unless it is ignited as uncontrolled nuclear fission.

Fusion is the source of stellar energy (i.e. the energy released by the sun and stars). The temperature of the sun's core is very high and fusion occurs by fusing the four hydrogen nuclei into helium. Although there are two different processes by which reactions occur in the stellar condition-a proton-proton cycle and a carbon-nitrogen cycle. But the energy released in both the cases comes out to be the same (about 24.6 MeV).

The sun is radiating energy at the rate of 10^{26} J sec.$^{-1}$. Thus, the loss of the matter occurrence from the sun is 4×10^{6} tonnes per second. But the sun has a very large mass (10^{30} kg) which will continue for several billion years.

Fluorescence : There are various types of substances occurring in our nature and on a few of them if a ultraviolet light of smaller wavelength but larger frequency incidents, then it is absorbed by them and emit a light of longer wavelength (shorter frequency) this incident or phenomenon is called fluorescence and the corresponding substances are called fluorescent substances.

The examples of fluorescent substances are fluorspar, petrol, quinine sulphate, uranium oxide etc. To detect X-rays we use barium platino cyanide which is a sensitive fluorescent substance on passing X-rays, through which it absorbs the X-rays and emits green light. Today in tube-light, the inner coating of fluorescent substances are laminated to get a fascinating and decorative flavour of the light.

Phosphorescence : As from the basic characteristic of fluorescence, substances which emit light until they are in absorbing position of suitable light of lower wavelength. But there are also some substances which not only emit the incident light at glance but is also remain emitting for some more longertime, even while its incidence is stopped. This is called phosphorescence and the corresponding substances are called phosphorescent substances. On heating, the ability and quality of the phosphorescent substance is completely destroyed.

The examples of the phosphorescent substances are zinc sulphide, calcium sulphide, barium sulphide etc. Today in the needle of watches and in various hoarding boards employed for the advertising and marketing purposes the lamination of the phosphorescent substances are used. These needles and hoarding boards absorb sunlight in the day and shine in very glazy and fascinating way in the night.

Superconductivity : The phenomenon of superconductivity was firstly invented in 1911 by a Dutch physicist K. Onnes. He experimentally observed that the electrical resistance of some metals, alloys and compounds drops suddenly to zero when the specimen is cooled down below a certain temperature called transition temperature (T_C). This phenomenon is called superconductivity and the specimen cooled down is called Superconductor. He also observed that resistance of the mercury vanishes completely at 4.2K. The critical (transition) temperature (T_C) below which a material undergoes a transition from a state of normal conductivity to a superconductivity is different for different materials. The normal good conductors like Cu, Ag, Au, Li, Na, K etc. do not exhibit the phenomenon of superconductivity even at more and more lower temperature. Thus, these are called normal metals. This implies that in general not all materials are superconducting.

Since the superconducting state of a material is characterised by the zero electrical resistance even in the absence of an applied voltage and the current can persist for years without any detectable decay. A bulk superconductor in a weak magnetic field acts like a perfect diamagnet with zero magnetic field into the interior. If a super conducting material is kept in a magnetic field and then cooled down below its critical (transition) temperature (T_C), it expels all the originally present magnetic flux from its interior and it is called *Meissner effect*. In fact this phenomenon was observed by W. Meissner and R. Ochsenfeld in 1933.

Also scientists from all over the world have been trying to develop the new materials that are superconducting at high temperatures. A break through in this regard come into existence when a hot superconductor was obtained in 1986. When Karl Alex Muller of *IBM'S* Zurich Lab made a substance of metallic oxide of lanthanum-barium-copper called ceramics that lost its electrical resistance at 30 K and it was called a hot superconductor. In 1987 the value of transition temperature (T_C) raised up to about 90 K when Paul Chu and his team discovered a ceramic copper-oxide superconductor, called cuprate consisting of Yttrium, barium and copper oxide.

Applications

(i) Large scale application of superconductor are in the transmission of power. The cables made from superconductors can save 30 to 40 percent power which is lost the conventional system of transmission. The solenoid of a superconductor can trap a large amount of electrical energy endlessly within itself.

(ii) Extremely sophisticated electronic devices such as Magnetic Resonance Imaging (*MRI*) scanners, superconducting Quantum Interference Devices (*SQUIDs*) etc. are today utilised frequently.

Theory of relativity

Michelson-Morley Experiment : According to the wave theory of light a light source sets up a disturbance transporting in all directions through a hypothetical medium called *ether* which fills up all the space and penetrates inside all the matter. But the assumption of ether created a problem. Does ether remain stationary in space when material bodies (including earth) move in it or is it dragged alongwith the moving bodies? But the observation of the aberration of light from the stars had indicated that the ether must be stationary in space, there is a relative motion between the body and the ether. A number of experiments were performed to detect a relative motion between the earth and the ether, Michelson-Morely experiment is one of them. Michelson-Morely by their experiment observed that the motion of the earth through ether is meaningless and it (ether) could not be experimentally detected.

Einstein's Special theory of relativity : In 1905 Einstein propounded his special theory of relativity which is explained as below—

(i) The laws of Physics have the same form in all the inertial frames moving with a constant velocity relative to one another. This is called principle of relativity. This postulate also confirms the absence of any concept of the universal reference frame.

(ii) The speed of light in free space is the same in all the inertial frames of reference. This is called principle of constancy of the speed of light. This postulate follows directly from the result of Michelson-Morely experiment.

An Inertial frame of reference : Any space-time rectangular co-ordinate system in which a body totally finds itself in rest anywhere is called an inertial frame of reference. The Newton's laws of motion are defined in this frame.

But if a body is not to be found to remain in the rest position or be in motion, then the frame of reference is called non-inertial. In non-inertial frame Newton's laws of motion are not defined and applicable.

VII. Electronics

The area of electronics has become very extensive in which broad and various electronic devices are frequently operative and through it agriculture, communication, medical sciences, defence, industry, space research, engineering, education etc are extensively studied. During the early time under the electronics vacuum tube diodes and triodes were used and that's why the equipments earlier than the nineteenth century like larger radiogrames etc. were noisy and inconvenient. Afterwards these vacuum tubes were replaced and discarded by the semi conductors and transistors and now solid state electronic devices have been fabricated and designed which are compact, cheapest, convenient and efficient. Now apart from these solid state electronic devices, Integrated circuits are utilised as microchips in the microprocessors and computers and are studied in the digital electronics segment.

Thermionic emission : Whenever a metallic wire or filament is heated strongly in vacuum then electrons start to emit and these electrons are called thermions, while the phenomenon of electron emission is called thermionic emission. The phenomenon of thermionic emission was firstly invented by Thomas Alva Edison in 1884. The vacuum tube diodes, triodes, pentode etc. had been fabricated on the principle of thermionic emission. The electrons are also obtained by thermionic emission in the x-rays tube and cathode rays tube.

Diode valve : In 1904 Fleming fabricated a device in which two electrodes–a cathode and an anode were inserted in a cylindrical glass valve which was fully evacuated. Here anode acts like a plate, while cathode acts like a filament and both are kept separate and attached through a pin. In this valve filament is made from metallic wire and on heating the plate (made of nickel) electrons are emitted. The nickel plate is in the cylindrical form which encloses cathode (filament). If a positive potential is supplied to the plate, the emitted electrons from the filament start to attract and accumulate around the cathode. The space around which electrons accumulate is called space charge region. Thus, when a +ve potential is supplied to the plate then electrons move towards the plate and a circuit is completed between the plate and filament and a current flows from the plate to filament. This is called plate current.

Diode valves are used as rectifier through which an alternating current (a.c.) is converted into a direct current (d.c.).

Triode valve : In 1907 Dr. Lee De Forest a USA based scientist fabricated a device which was similar to the diode valve alongwith which another element called control grid was attached. In other words, if in a diode valve an additional electrode is attached to control the thermionic emission in an evacuated (vacuum tube) tube it is called a triode valve. Thus there are three electrodes (plate, filament, grid) in a triode valve and this valve is utilised in the form of amplifier, oscillator, modulator, transmitter and detector.

Semi-conductor : A semi-conductor is a solid material whose electrical resistivity is higher than that of a conductor and lower than that of an insulator. Typical values of the resistivity of a semi-conductor lie between 10^{-12} to 1 ohm - meter at room temperature. The electrical resistance of a semi-conductor decreases with increase in temperature over a particular temperature - range which is the specific characteristic of a semi-conductor. The relation between the resistance R and absolute temperature T for a semi-conductor is given by

$$R = Ae^{\frac{B}{T}}. \qquad \text{where the } A, B \text{ are constants}$$

Thus a semi-conductor has a negative temperature coefficient and this behaviour is contrary to that of a metallic conductor for which resistance increases with the rise of temperature. At ordinary temperature the pure semi-conductor has very small conductivity and this semi-conductor is called intrinsic semi-conductor. At 0 K all the semi-conductors are in pure form and behave like insulators. But the electrical conductivity of a semiconductor can be increased by a large value by addition of a small amount of suitable impurity called doping. Usually if 1 atom of an impurity is dopped to a pure (intrinsic) semi-conductor of 10^6 atoms, its conductivity increases 16 times and this semi-conductor is called impure or extrinsic semi-conductor.

Broadly there are three elements, silicon (Si) Germenium (Ge) and grey tin (Sn) in their crystalline form which are extensively used as semi-conductors. But Ge and Si are the most widely used semi-conductors in the fabrication of the solid state electronic devices. There are also numerous semi-conductor compounds like $GaAs$, $PbSe$, ternary alloys etc.

Extrinsic semi-conductor : As from earlier discussion a pure semi-conductor is a poor conductor of electricity and that's why it is made impure to increase the electrical conductivity by doping impurity. This impure semi-conductor is called an extrinsic semi-conductor. But the doping of the impurity also depends on the types of impurity.

Thus there are two types of extrinsic semi-conductors depending upon the nature of the impurity mixed up.

(i) *n*-type semi-conductor : If a pentavalent element (impurity) like phosphorous, arsenic, antimony etc. is dopped or mixed in *Ge* and *Si*, then five valance electrons of the pentavalent impurity form a covalent bond and one electron becomes mobile due to which it (electron) acquires a certain energy in excitation form. Thus electron becomes free and it goes to the conduction band from the valance band. Such semi-conductors are called *n*-type and electrons are called majority charge carriers and since surplus electrons are supplied by the impurity (pentavalent) so impurity is called donor impurity. Also due to the release of electrons from the valance band a vacancy is created and it is filled by the another electrons and thus a hole (positive charge carrier) is created which is also respondent for the conductivity. These holes are called minority charge carriers for *n*-type semi-conductor. But over all, *n*-type semi-conductor is a neutral crystal.

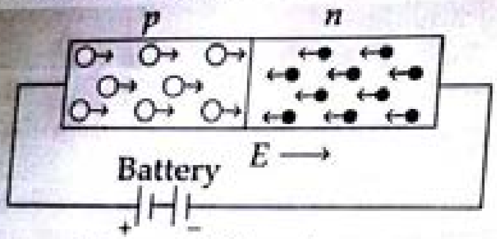
(ii) *p*-type semi-conductor : If a trivalent element (impurity) like indium boron, gallium or aluminium etc, is dopped or mixed in *Ge* and *Si*, then three valance electrons of the trivalent impurity form a covalent bond and from anywhere of *Ge* and *Si* an electron becomes available for the trivalent atom and thus four covalent bonds form. But due to an electron availability for the trivalent atom any covalent bond of *Ge* or *Si* breaks and a vacancy is created as a hole (positive ion). Due to large holes creation and its conduction these conductors are called *p*-type semi-conductor. Since electrons are accepted by the trivalent impurity and mainly conductivity is done by the holes, that's why such impurity is called acceptor impurity and holes are majority charge carriers for *p*-type semi-conductors. Also some electrons become available and are respondent for a few conduction is called minority charge carrier but over all *p*-type crystal (semi-conductor) is also neutral.

***pn*-junction or semi-conductor diode :** Pure or impure semi-conductors are bilateral electronic equipment through which the current flows in either direction with equal magnitude. Although if in a semi-conductor there exists a *p*-type region on one side and a *n*-type region on the another side then the semi-conductor becomes unilateral and the current flows easily in only one direction. The specific location in the semiconductor where the region changes from *p*-type to *n*-type (the lattice structure remaining continuous) is called a *pn*-junction. The semi-conductor containing a *pn*-junction is called semiconductor diode.

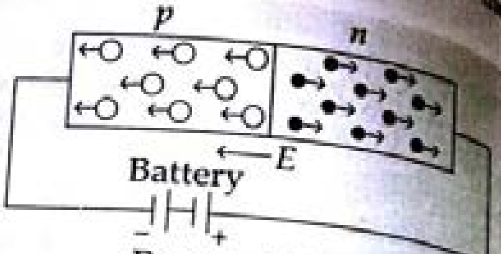
A *pn*-junction is not the interface between the two pieces of the semi-conductor of the opposite types pressed together. It is a single piece of semi-conductor crystal having an excess of donor impurities into one side, and of acceptor impurities into the other. By four methods, *pn*-junctions are fabricated and designed which are growing, alloying, diffusing an ion implantation. The thickness of the *pn*-junction is of the order of 10^{-6} meter.

Forward biased and Reversed biased *pn*-junction :

If in a *pn*-junction, a *p*-type crystal is connected with the positive terminal of the battery and a *n*-type crystal is connected with the negative terminal of the battery, then it is said to be in forward biased position and at this position a large amount of current flows unilaterally through the junction due to the creation of an external field E.



Forward Biased



Reversed Biased

But if in a *pn*-junction a *p*-type crystal is connected (attached) with the negative terminal of the battery and a *n*-type crystal is connected (attached) with the positive terminal of the battery, then it is said to be in the reversed biased position and at this position only very small amount of current flows due to the minority charge carriers through the junction.

Applications of *pn*-junction :

(i) As a rectifier : In the absence of any external voltage applied across a *pn*-junction, there is no current in the diode. Under this condition a few majority charge-carriers (holes in *p*-region and electrons in *n*-region) have sufficient energy to move across the junction despite the opposing internal field and form a forward current. This current is however exactly balanced by the reverse current formed by the flow of minority carriers (electron in *p*-region and holes in *n*-region) across the junction which is supported by the internal field. The net current is thus zero, this is the action of a rectification. Thereby *pn*-junction acts like a rectifier in which an alternating current (a.c.) is converted into a direct current (d.c.).

(ii) As a Zener diode : When *pn*-juction is in a reverse biased condition then it acts like a zener diode for a long voltage range and it is used as a voltage stabliser.

(iii) As a Tunnel diode : A tunnel diode is a semi-conductor device (*pn*-junction diode) which makes use of the a quantum mechanical phenomenon of the potential barrier penetration. It is a *pn*-junction which is made from a heavily dopped semi-conductor.

(iv) As a Photo conductor : A photo conductor is a device that detects optical signals. A commercial photo conductor is called a photo conductive cell and has a layer of cadmium sulphide (CdS) containing a small amount of bismuth or indium impurity on its sensitive surface. When a light falls on the surface of the photo conductor, the current in the circuit increases depending upon the intensity of the incident light.

Photo conductive devices or cells are used in industry, photography and light-intensity measurement. The most commonly used cell is the cadmium sulphide (CdS) photo conductive cell which is excellently sensitive in the visible range. A lead sulphide (PbS) or indium antimony ($In\ Sb$) cell is used for the infrared detection. A selenium cell is particularly sensitive in the blue region. *PN*-photo diode is a junction type photo conductor having several advantages over an ordinary bulk-type photo conductive cell.

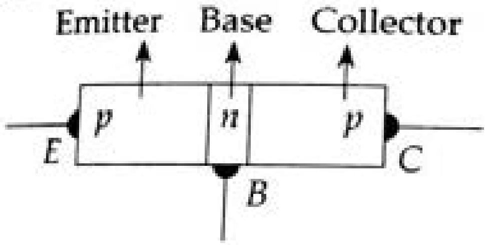
(v) As a Solar cell : A solar cell is a semi-conductor device (*pn*-junction) which converts the solar energy directly into the electrical energy and it is based upon the phenomenon of photo voltaic effect. The commercial solar [illegible] crystal and it is used in space vehicles where a small mass of the solar batteries is needed or inaccessible places on the earth where automatic equipments/devices are kept non-stopped operating.

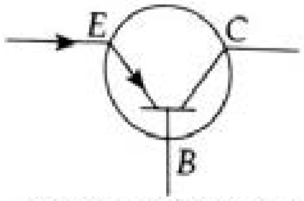
Junction Transistor or Bipolar Transistor : A junction transistor is a semi-conductor device consisting of two *pn*-junctions placed back to back, one under a forward bias and another under a reverse bias. A forward-biased *pn*-junction offers a low resistance, while a reverse-biased offers a high resistance. Also in junction transistor both majority and minority carriers play a significant role and that's why it is also called bipolar transistor and it is a solid state electronic control device.

Such point contact transistor was firstly invented by John Bardeen and Walter Brattain in 1948. But these transistors were found to have the problem in their fabrication. Also these were found to be electrically noisy and lacked a larger power gain. Thus, a modified and comprehensive approach was taken for its commercial fabrication and design by William Shockely in 1951. Thus, on the commercial level the real inventor of the bipolar junction transistor was William Shockely. At present some more modified techniques of its fabrication and designing have been developed and these techniques are zone refining, diffusion, epitaxial, planar, beam-lead, ion implantation etc.

The junction transistor is of two types—*pnp* transistor and *npn* transistor.

***pnp* transistor :** It consists of a very thin slice of *n*-type semi-conductor sandwiched between small block of *p*-type semi-conductor. The central slice is called base, while the left and right blocks are called emitter and collector.

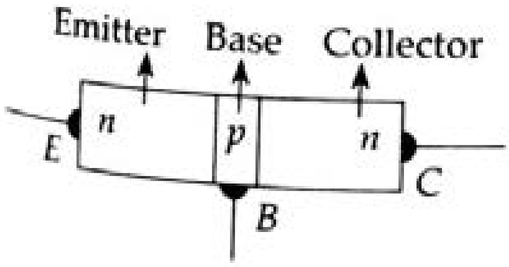


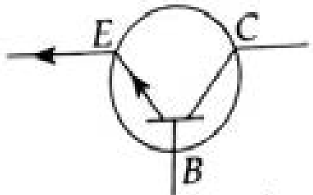


pnp transistor (symbol)

The emitter is given a positive potential, while the collector is given a negative potential with respect to base. Thus the emitter-base (*p*–*n*) junction is under forward-bias (low resistance), while the base-collector (*n*-*p*) junction is under reverse-bias (high resistance).

***npn* transistor :** It consists of a thin slice of *p*-type semi-conductor sandwiched between two small blocks of *n*-type. In this transistor the emitter is given a negative potential, while the collector is given a positive potential with respect to the base. Again the emitter-base (*n*-*p*) junction is under forward bias, while the base-collector (*p*-*n*) junction is under reverse-bias.





npn transistor (symbol)

In working position for every bipolar junction transistor *pnp* **or** *npn*

Emitter current (I_e) = Base current (I_b) + collector current (I_c).

There are three modes of configuration for the working of a junction transistor as given below :

(a) Common base configuration.

(b) Common emitter configuration.

(c) Common collector configuration.

Unipolar transistor or Field Effect Transistor (*FET*) : A Field Effect Transistor (*FET*) is a semi-conductor electronic device in which the current is controlled by the variation of an electric field and is carried out by the majority charge carriers only. Like a vacuum tube, the *FET* is a unipolar (one type of carrier) device. There are two types of field effect transistors—Junction Field Effect transistor (*JFET*) and Metal-Oxide-Semi-conductor Field Effect Transistor' (*MOSFET*). There are two classes of *JFETs*—*n*-channel *JFET* like a thermionic tube (triode valve), *FET* is a voltage-controlled device, while the conventional transistor uses a base current to control the large collector-current. That's why bipolar junction transistor is a current-controlled device. Also *FET* is less noisy than a bipolar transistor so it is frequently used in *FM* (Frequency Modulated) radio. *FETs* have smaller size and longer life. Hence, a large number of them are incorporated today in the Integrated Circuits (*IC*), while bipolars are cheaper and offer a larger range of choice which are used in the discrete circuits (digital electronics).

Application of transistors : Almost all the solid state electronic control devices are made from the bipolar or unipolar junction transistors. Some electronic devices which use junction transistors directly are power amplifiers, voltage amplifiers, oscillators, modulators etc.

Also some *FETs* are specially used as switches in the digital circuits, as a phase-shifter in the oscillator circuit and as a Voltage Variable Resistor (*VVR*) which is used in an attenuator circuit, an automatic gain control circuit etc.

Modern electronic devices

(i) Cathode Ray Oscilloscope (CRO) : Cathode Ray Oscilloscope (*CRO*) is one of the most widely used device having a large number of applications. A cathode ray oscilloscope consists of the following main components—cathode ray tube, horizontal and vertical voltage amplifiers, power supply circuits etc.

Both the a.c. and d.c. voltage can be measured through a *CRO* and it is used in the television receiver and Radar. It is also used for radio servicing and to locate the falts in various electronic equipments. It is used also in the construction of electro cardiograph and in the industries to study the mechanical pressure and to get the indicator diagrams of the internal combustion engines. *CRO* is also used in measuring an extremely short interval of time even less than a micro second.

(ii) Television : Television was firstly invented in 1923 by John L. Baird through which both sound and light were are transmitted in the form of an electromagnetic wave by the means of resonance from any suitable place. In other words pictures, scenes and photographs of moving objects vehicles etc are transmitted in the form of an electromagnetic wave through the picture tube and by the means of an amplified modulation these are picturised on the television screen.

Broadly there are two parts in the television :—

(i) Iconoscope : Iconoscope transforms the scattered light wave of the picture of any object into an electromagnetic wave which is transmitted to the far flung distances and places by an amplified modulation mechanism.

(ii) Kineoscope : It is a type of Cathode Ray Oscilloscope (CRO) through which cathode ray adjusts the tuning similar to the iconoscope and produces a resonance with an amplified, modulated electromagnetic wave. Consequently fascinating, fluorescent pictures and scenes due to the persistence of the vision appear.

(iii) RADAR (Radio Detection and Ranging) : The Radar was firstly invented by Robert Watson but its first prototype was designed by the two American scientists Taylor and Young. It is a device through which the actual location (position) and the configuration of the unwanted bodies are detected and measured by the electromagnetic wave of the flying aircraft at higher altitudes.

The radars are also used to detect and measure the position (or location) and distance (or height) of the cloud, to explore the evidence of any metal or oil reserve, to detect the outer layer of the atmosphere and to obtain the height of ionosphere etc.

(iv) LASER (Light Amplification by Stimulated Emission of Radiation) : Laser is a device that produces an intense, coherent and highly directional beam of the single frequency. It can be transmitted over a great distance without being spread. The light beam can be intense enough to vaporise the hardest and the most heat resistant materials. The first ruby laser was demonstrated by Theodore H. Miaman in 1960. Any laser device consists of three main components— an active medium, a pumping source and an optical resonator. All lasers work on a basic principle that whenever electricity, heat, light or chemical reaction excites an atom it accommodates the extra energy by rearranging its electrons, shifting some of them from the ground energy level to higher energy levels. This excited state of electron is unstable and to become stable the electron falls back to its ground state emitting extra energy in the form of light. This kind of emission is called stimulated emission. The important kinds of lasers include optically pumped lasers, liquid lasers, gas discharge lasers, semi-conductor lasers etc. Laser works up to femto (10^{-15}) second, while super fast computer works only up to nano (10^{-9}) second.

Applications of Laser :

(i) In Information Technology (*IT*) : Laser is frequently used in the fabrication and composition of *CD* (Compact Disc), *DVD* (Digital Versatile Disc) and in the collection of datas and its storage in *CD*.

(ii) To measure time and distance : By the help of laser both distance and time can be measured most accurately and precisely. Also through it not only the longest distance is to be measured accurately but also the smallest distances, even interatomic distances, are measured in the most excellent and accurate form. That's why by the laser interatomic distances and so internal structure of the atoms are authentically studied.

(iii) To construct hologram : With the help of laser a special type of three dimensional photograph is drawn in the hologram form.

Holography : Dennis Gobar firstly invented a three dimensional photograph (complete view of an object) which is not possible through any camera lens system by the means of a highly coherent light. Thus, the complete resemblance of an object in a very distinct manner is sketched and in which the originality of the object appears is called holography. In holography we do not record the object (being photographed) but record the light waves reflected from the object. This photographic record is called a *hologram.* The hologram has no resemblance with the object, although it contains all the informations about it in the form of an optical code. When this hologram is illuminated by a source of coherent light a three dimensional photograph of the object is formed. Thus, in holography we do not use any lens (or camera) and obtain a perfect (excellent) and original touch of the object in its photograph. This photography technique was firstly utlised in 1962 by Y.N. Denisluk after the invention of laser in 1960.

(iv) To sketch the path (trajectory) of flight : For the security point of view the accurate path of the aircrafts and aeroplanes are sketched through a powerful laser which is very convenient for the air traffic control and comfortable journey. Also rockets and satellites follow this technique for their smooth and perfect destinations in the space.

(v) In Industry : In the industrial sector lasers are mainly used in surveying, to facilitate data network, the processing of objects or commodities, to examine non-decomposed substances etc. Today lasers are also utilised frequently in cutting an extremely hard object, cloth, in the construction of buildings, metallic pipes, in the exploration of mines, in the furnishing of diamonds and gems jewellery. By the means of a special laser cutting technique the diamond's look has been made more fascinating and stylish.

(vi) In defence : The lasers are used to measure the accurate position and distance of the missiles and other sophisticated weapons. Under the *star war programmes,* the destructive power of the laser is being utilised to destroy missiles in the sky.

(vii) In chemistry : In chemistry lasers are used as remedial equipment and in the chemical reactions lasers are used as a catalyst or an autolyst.

(viii) In health and medical science : Today lasers are playing a significant and relevant role specially in the incurable and undiagonised diseases. Through the laser today cancer has become curable, the barrier produced in the blood clotting in the veins of heart is being sorted out, and many surgical operations in human eye are being completed without any complicacy and problem in perfect way. Specially in the treatment of eye a modern technique which is called *Eximer Lassic Laser,* through it the human eye glass can be permanently discarded (abandoned). Argon or krypton ion lasers are also frequently used in the treatment of the retina of the eye and some other problems of the human eyes. The *laser radial keratotomy techniques* are used to adjust the abnormal shape of the eye lens. Through the laser and *optical fibre endoscope* the blood clotted ulcers have easily become curable in a very convenient and simple way. By laproscopic treatment the stones of gall bladder and kidney are removed without any rigorous surgical work in a very short interval of time.

MASER (Microwave Amplification by Stimulated Emission of Radiation : The maser was invented by three American scientists Gordon, Gieger and H. Townes in 1952 and it is similar to the laser upto maximum extent. In fact maser is an optical device which uses microwave in apmlified form of longer wavelength of the light, while ordinary laser uses light rays simply.

Through masers the actual position of the artificial satellites, fighter planes, unwanted missiles etc are detected by the help of the radar. In ocean water masers are today utilised to communicate some important messages and details needed. Also through the masers remedial measures are performed similar to the lasers.

Laser technology in India : In 1964 the first laser as Gallium Arsenide (GaA) semi-conductor laser was designed and fabricated by Bhabha Atomic Research Centre (BARC). The BARC is the largest centre for developing laser technology in a very exclusive way in India. The lasers developed so far are *He-Ne* laser, *He-Cd* laser, copper vapour laser, ruby laser etc. Some other centres where lasers are designed and fabricated are Centre for Advanced Technology (CAT), Defence Research and Development Organisation (DRDO), Indian Insititutue of science (*I I Sc.*) Banglore, and Indian Institute of Technology (*IIT*) Kanpur. An exclusive centre for the laser research is *IIT*- Kanpur whose laboratories are too much enriched and where research works on the laser plasmas, quantum optics, ultrafast process, nonlinear optics etc are going on with the American Collaboration.

Miscellaneous

1. Important Physical quantities and their units

Physical quantity	Unit (S.I.)	Physical quantity	Unit (S.I.)
Length	Metre	Sp. heat capacity	Joule/kg-K.
Time	Second	Electric power	kilo Watt hour (kWh)
Volume	Cubic metre	Electric resistance	Ohm
Velocity	Metre/sec.	Electric potential	Volt
Force	Newton	Latent heat	Joule/K
Pressure	Pascal	Surface tension	Newton/metre
Energy	Joule	Moment of inertia	kg. m^2
Temperature	Kelvin	Electric charge	Coulomb
Mass	Kilogram	Electric capacity	Farad
Density	kg/m^3.	Power	Joule/sec or watt
Heat	Joule	Viscosity	Newton-sec. metre^{-2}
Electric current	Ampere	Work	Newton-metre or Joule
Area	Sq. metre	Luminous Intensity	Lumen

Physical quantity	Unit (S.I.)	Physical quantity	Unit (S.I.)
Frequency	Hertz	Linear momentum	Newton-sec.
Wavelength	Metre	Magnetic flux	Weber, Maxwell
Speed	metre/sec.	Power of the lens	diopter
Acceleration	metre/sec^2.	Angular velocity	rad/sec.
Plane angle	radian	Solid angle	Steradian
Intensity (in sound)	decibel	Luminous Intensity	Candela
Absolute temperature	Kelvin	Atmospheric pressure	Bar
Potential difference	Volt	Astronomical distance	Light year
Electric field intensity	Newton/Coulomb	Supersonic motion	mach
Magnetic dipole moment	Ampere-metre	Acceleration due to gravity	metre/sec^2.
Magnetic field or magnetic induction	Tesla, weber-per metre^2		

2. Conversion Units

One inch	2.54 cm	one foot	0.30 meter
One yard	0.91 meter	one mile	1.60 km
One fadam	1.8 meter	one chain	20.11 meter
One nautical mile	1.85 km	one angustrum	10^{-10} meter
Square inch	6.45 square cm	Square foot	0.09 square meter
Square yard	0.83 square meter	one acre	$10^4 m^2$
Square mile	2.58 square km	one cube inch	16.38 cm^3
Cube foot	0.028 cube meter	one yard	0.76 m^3
One liter	1000 cm^3	one pint	0.56 liter
One grain	64.8 mili gram	one drum	1.77 g
One ounce	28 gm	one pound	0.45 kg
One erg	10^7 Joule	one poundal	0.13 Newton
One calorie	4.2 Joule	one horse power	746 watt
One Newton	10^5 dyne	one fadam	6 feet
One nautical mile	6080 feet	one mile	5280 feet
One mile	8 farlang	one yard	3 feet
One foot	12 inch	50°C	122°F
37°C	98.6°F	32°F	0°C
−40°C	−40°F		

1. Scientific devices/equipments

Devices/Equipments	Use
Ammeter	Electrical devices employed to measure current in ampere.
Altimeter	The device that measures the altitudes of aircraft.
Audiometer	The device that measures the intensity of sound.
Audiophone	The device or equipment employed in the ears by which the process of listening becomes easy and appreciable.
Animometer	The device through which the power and speed of wind are measured.
Avometer	The device used to detect any fault in radio.
Airometer	The device used to measure the weight and density of air and gases.
Accumulator	The device used to restore electrical energy.
Ascalator	Moving mechanical ladders.
Apicoiscope	The device/equipment used to display the opaque (in transparent) photo on the screen.
Aviontiometer	The device used to detect and measure the intensity of sunrays.
Adiometer	The equipment through which the distances travelled by the wheels of vehicles are measured.
Barometer	The device used to measure atmospheric pressure.
Barograph	The device used to measure atmospheric pressure and used to focus on autographics.
Bolometer	The device used to measure thermal radiations.
Binoculars	The device used for the magnification of objects.
Crescograph	The device through which the growth in plants is detected and measured.
Calorimeter	The device used to measure the amount of heat.
Cardiogram	The device used to measure the heart beats of human body.
Carburator	The equipment used in internal combustion heat engine, vehicle's engine etc.
Compass-box	The equipment used to detect the North-South direction of any place.
Cyclotron	The device used to accelerate positively charged particles, ions etc.
Cytotron	The device by which artificial climate is produced.
Callipers	The device through which the external and the internal diameters of the cylindrical objects are measured.
Cathode ray tube	The equipment through which electrons are emitted or ejected.
Coolidge tube	Modern *X*-ray tube (device) used for various purposes.

Devices/Equipments	Use
Chronometer	The equipment employed in ships/steamers to measure the right time.
Cardiograph	The equipment through which human's heart beats are recorded and detected through graphics.
Denial cell	The device used to flow direct current (dc) through the circuit.
Density meter	The device used for density measurement.
Dynamometer	The device through which the power generated by an engine is measured.
Dictaphone	The device used to record own statement to listen another.
Dynamo	The device used to convert mechanical energy into electrical energy.
Dip circle	The device used to measure the angle of dip.
Dialysis Machine	The device used in blood purification for the person suffering through cardio related problems.
Dialetometer	The device used to measure the change in volume.
Electroscope	The device that confirms the presence of electric charge.
Electro meter	The device used to measure the potential difference (pd).
Electric motor	The device used to convert electrical energy into mechanical energy.
Electron microscope	The equipment used to analyse the micro substance.
Epidayscope	The equipment employed to project or expose pictures on the screen.
Electroinsifle graph	The mechanical device used to measure the potential of the human mind.
Endoscope	The device through which inner parts of the human body is diagnosed.
Fethometer	The device used to measure the depth of seas and oceans.
Geiger Mullar counter	The device used to measure the radiation of a radio active substance.
Gravometer	The device used to detect the presence of oil on water surface.
Gyroscope	The device used to obtain the speed and orientation of a moving object.
Galvanometer	The device used to measure the sharpness of electric current.
Gramophone	The device used to reproduce sound by sound wave.
Ganong respiratory	The device used to measure the respiration coefficient.
Hydrophone	The device used to measure the sound waves inside water.

Devices/Equipments	Use
Heart lungs machine	The device used in surgical operations of heart and lungs.
Hygrometer	The device used to measure atmospheric humidity.
Comograph	The equipment to used depict the motion of the heart beat in graphics way.
Calidoscope	The equipment used to detect various type of geometrical figures.
Lactometer	The device used to detect and measure the purification of milk.
Loudspeaker	The device used to enhance sharply the slow voice and loud voice is listened.
Lightening Conductor	The equipment employed and installed in multistoried buildings to protect the building from thundering lightening.
Megaphone	The device used to throw sound or voice remotely.
Microphone	The device used to transform sound energy into electrical energy.
Micrometer	The device used to obtain the $\frac{1}{1000}$th part of a milimeter.
Microtom	The equipment through which any substance is cut into the very smaller pieces.
Manometer	The device used to measure the pressure of gases.
Machmeter	The device through which the speed of air is expressed as in the form of the speed of sound.
Oscilliograph	The device through which electro mechanical vibrations are depicted graphically.
Ondometer	The device through which the frequency of an electromagnetic wave is measured.
Phonograph	The equipment through which sound writing is composed.
Photometer	The device through which the illumination and intensity of two light sources are compared.
Phototelegraphic	The equipment through which any photograph is brought from one place to another.
Pyrometer	The device used to measure extremely high temperature (temperature of the sun, star)
Periscope	The device used for those objects which are beyond the purview of looking range but through it objects are made easily to be seen.
Phonometer	The device used to know the power of brightness of light.
Pipate	The thin tube shaped equipment which measures the fixed volume of liquids.
Parasuit	The equipment used to fall on the earth's surface from higher altitudes from aircrafts during an emergency.

Devices/Equipments	**Use**
Photometer	The device through which the rate of evaporation of water is measured.
Polygraph	The device through which the truth of a human being is examined.
Paicnometer	The device used to measure the density of liquids and coeff. of linear expansion.
Quadrant	The device used to measure the altitudes and angles in navigation and astronomical science.
Radiator	The device used to cool the engine of vehicles.
Radiometer	The device used to measure thermal radiations.
Rain Gauge	The device used to measure the amount of rain of a certain place in a specific time.
Radar	The device used to measure the speed and direction of far coming aircrafts and fighter planes.
Refractometer	The device used to obtain the refractive indices of the transparent media.
Radio Micrometer	The device used to measure the thermal radiations.
Safety lamp	The device used in mines to avoid mines related mishaps.
Sextant	The device used to measure altitude
Stroboscope	The device with which the speed of a body is measured which executes the periodic motion.
Submarine	The equipment (water ship) which detects marine activities inside the ocean or sea water.
Sifgmoscope	The device through which human pulse vibration is measured.
Sphygmomanometer	The device used to measure the blood pressure of the human body.
Secrometer	The device used to measure the concentration of sugar.
Speedometer	The device used to measure the speed of motor vehicles.
Scrue Gauge	The device used to measure the diameters of thin wires.
Stop-watch	The device used to record true and accurate time.
Seismograph	The device used to measure the intensity of the earthquake.
Stethoscope	The device used to listen to the vibrations of the heart and lungs.
Spectroscope	The device used to analyse the spectrum.
Sterioscope	The device used to sketch two dimensional photographs.
Spherometer	The device used to measure the curvature.
Sphygmophone	The device used to listen the fast pulse vibrations.
Tokometer	The device used to measure the speed of the aircraft.

Devices/Equipments	Use
Transformer	The device used to regulate (high or low) AC voltage.
Telemeter	The device used to record flung physical incidents.
Teleprinter	The device used for receiving telegraphic massages and auto print technique with itself.
Thermostat	The equipment used to regulate the static temperature.
Telex	The device used to do direct conversation between two countries.
Theodolight	The device used to measure the cross-sectional and rectangular angles.
Taximeter	The equipment that displays directly the fare of the passengers.
Thermopile	The device used to measure the intensity of the radiation.
Turbine	The device used to transform the kinetic energy of the fluid into rotational energy and then the mechanical work is done.
Tokiometer	The device used to measure distance, latitude specially during survey and this device is like Thiodolight.
Ultrasonoscope	The device used to detect tumour, and some problems of the heart.
Udometer	The device used to measure the amount of rainfall.
Viscometer	The equipment used to measure the viscosity of the liquids.
Vacuum-cleaner	The equipment used to remove the dust particles.
Videophone	The device used in which alongwith voice (sound) of telephone photo also appears.
Van-de-graph generator	The device through which high potential difference is produced.
Venturimeter	The device through which the speeds of flow of liquid are measured.
Wattmeter	The device used to measure electric power.
Wavemeter	The device through which the wavelength of the radiowave is measured.
Xylophone	The device of a new musical instrument.

4. Inventors related to devices/equipments

Device/Equipment	Inventors	Device/Equipment	Inventors
Television	J.L. Beared	Radio	Marconi
Barometer	Torricelle	Telegraph	Morse
Lens camera	Jeans	Aeroplane	Wright brothers
Tyre	Dunlop	Seftipin	Walter Hunt
Telescope	Hans Lippershey	Thermionic triode	Leco Duo Forest
Revolver	Colt	Thormas Flask	Dewar

Device/Equipment	Inventors	Device/Equipment	Inventors
Military Tank	Swington	Rail engine	George Stefans
Dialysis Machine	Colf	Steam boat	Frank Wheetal
Electric Bulb	Edison	Arc lamp	Devi
Spectroscope	Bunsen	Lift	F.G. Otis
Transistor	Shaklay	Dynamo	Micheal Faraday
Fountain Pen	Waterman	Radar	Robert Watson
Gyroscope	Foucalt	Submarine	Bushwel
Transformer	Faraday	Bi-cycle	Macmillan
Tape Recorder	Poulsan	Seftirezor	Gillette
Crascograph	J.C. Bose	Parasuit	A.G. Gagreen
Steam Engine	James Watt	Sextant	Compel
Motor Vehicle	Asteen	Ball pen	John J. Bond
Gramophone	Edison	Electric fan	Wheelar
Vapour turbine	Parsons	Machine gun	James Puckle
Telephone	Graham Bell	Printing Machine	Kaekstan
Calculator	Pascal	Refrigerator	Harison & Kaitlin
Holography	Denish Gobar	Petrol car	Karl Benz
Helicopter	Bracket	Wireless Telegraphy	Marconi
Gas Engine	Daymlar	Sismometer	Robert Mallet
Cyclotron	Lawrance	Micrometer	William Gas Cogin
Power loom	Carl Wright	Lightening conductor	Franklin
Diesel Engine	Rudolf Diesel	Thermionic diode	J.A. Fleming
Type Machine	Soldz	E-Mail	ReTomlinshon
Scooter	G. Brousa	Chronometer	John Harisson
Glider	Sir George Faily	Microscope	Janson & Janson
Jet engine	Frank Wheetal	Printing technique	Gu tenberg
Nuclear furnace	Aneriko Fermi	Heart Lung machine	Denish Mailrose
Thermometer	Fahrenheight	Air conditioner	Wills Hevyl & Carriare
Air break	George Wasting house	Gieger Mullar Counter	Gieger
Photometer	Adberd Charles Pikring		

5. Inventions in Physics/Inventors

Inventions	Inventors	Inventions	Inventors
Speed of light	Fizeou	Diode valve	J.A. Fleming
Mica sheet	C.R.T. Wilson	Triode valve	L.D. Forest
Electronic charge	Millikan	Dynamite	Alfred Nobel
Neutrino	Pauli	Laser rays	T.H. Memon
Safety lamp	H. Devi	Photon	Einstein

Inventions	Inventors	Inventions	Inventors
Radioactivity	H. Becquarel	Induction coil	Roamcorf
Law of pressure	Pascal	Law of Gravitation	Newton
Superconductivity	K. Onnes	Law of cooling	Newton
Corpuscular theory of light	Newton	Newtons' laws of motion	Newton
Law of refraction of light	Snell	Artificial disintegration of atom	Fermi
Principle of relativity	Einstein	Principle of Floatation	Archemedes
Thermal effect of electric current	Joule	Nuclear fission	Ottohaan and Strassman
Speed of light in liquid	Foucalt	Interference of light	Thomas Young
Current electricity, Electric battery	Alexander Volta	Electric charge	Benzamine Franklin
Static electricity	Thels	Maser rays	Gorden, Geeger
Modern X-ray tube	Coolidge	Wave theory of light	Hygens
Law of electric resistance	Ohm	Law of electric attraction	Coulomb
Electromagnetic wave	Henric Hertz	Logrithm	Briggs, J. Nappier
Thermionic emission	Thomas Alva Edison	Mechanical equivalent of heat	Joule

6. Eminent Physicist and their outstanding contributions

Physicists	Countries	Outstanding Contributions
A. Fermi	Italy	Identification of artificial radioactive elements, Atomic furnace construction etc.
A. Salam	Pakistan	Gave intercorelation between electro-magnetic forces and weak forces.
Archemedes	Greece	Propounded concept of upthrust (boyancy) in liquids, provided principle of lever, discovery of sp. gravity etc.
Aryabhatt	India	An eminent mathematician and astronomer of 5th century, some more special contribution in mathematics.
Bhaskar-I	India	A famous astronomer and mathematician of 7th century.
Bhaskar-II	India	A famous astronomer and mathematician of 12th century.
B. T. Nag Choudhary	India	The colleague of Dr. Lawrence who was the inventor of Cyclotron has special contribution in the nuclear physics etc.

Physicists	**Countries**	**Outstanding Contributions**
Copernicus	Poland	Discovery of the solar system, firstly to explain that all celestial bodies are revolving around the sun.
C. V. Raman	India	Raman effect, related to scattering of light, special research on crystallography of solids.
Dr. Raja Ramanna	India	Contribution in 1st nuclear explosion (Atom bomb) of India at Pokharan in 1974.
Dr. V. Sarabhai	India	Space research, cosmic rays research etc.
de-Broglie	France	Dual nature of matter (matter as a particle and matter as a wave).
Denish Gobar	U. K.	Discovery of three dimensional photography (holography)
Dr. Adberd Taylor	U. S. A.	Construction of hydrogen bomb (Fussion bomb)
Einstein	Germany	Comprehensive and special theory of relativity, explanation of photo electric effect, gave mass energy equivalence relation ($E = mc^2$), discovery of photon etc.
Galelio	Italy	Law of inertia, Kinematical equations, discovery of telescope etc.
G. Marconi	Italy	Wireless telegraphy, radio and wireless message.
H. Devi	U. K.	Discovery of safety lamp.
H. Cauvendish	U. K.	Determination of the density of the earth.
Heisenberg	Germany	Principle of uncertainly, propounded theory of Quantum mechanics.
H. A. Baithe	U. S. A.	Explanation of stellar energy (energy confined within stars).
H. Yukawa	Japan	Discovery of elementary particle meson.
H. J. Bhabha	India	The father of Indian Atomic energy, special contribution in space and cosmic-rays showers.
J. J. Thomson	U. K.	Discovery of electron
James Chadwick	U. K.	Discovery of Atomic neutron
John Dalton	U. K.	Proposed Atomic model
J. Kepler	Germany	Planatory motion, motion of satellites etc around the sun
J. B. Narlikar	India	Propounded new theory of relativity.
J. C. Bose	India	Discovery of crescograph, wireless messages, discovery of intrinsic sensation of plants.

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Physicists	Countries	Outstanding Contributions
K. M. Krishnan	India	The colleague (associate) of Dr. C. V. Raman in the invention of Raman effect.
Max Planck	Germany	Propounded Quantum theory.
Millikan	U. S. A.	Determine electronic charge, analysis of cosmic rays.
M. N. Saha	India	Principle of thermal ionisation.
Maxwell	Scotland	Electromagnetic theory of light, the law of molecular speed distribution.
Niels Bohr	Denmark	Propounded hydrogen line spectrum, first success in atomic model, quantum theory of radiation etc.
Newton	U. K.	Universal gravitational law, laws of motion, reflecting telescope, discovery of calculus, Binomial theorem etc.
Otto Haan	Germany	Construction of atom bomb (Fission bomb)
Robert Watson	U. K.	Discovery of radar.
Roentgen	Germany	Discovery of X-rays.
R. P. Finmen	U. S. A.	Research activities in Quantum electrodynamics.
S. Chandrashekhar	India	Astronomy (Chandrashekhar's limit), floatation physics, general relativity theory etc.
Satish Dhavan	India	Research activities in nuclear physics, special contribution in space research, has special role in Indian artificial satellites Aryabhat and Rohini.
S. Ramanujan	India	A special contribution in the theory of number system and algebraic inequalities.
S. N. Bose	India	Discovery of boson (an elementary particle).
T. Alva Edison	U. S. A.	Phonograph, electric bulb, picture telegraph (discovery), discovery of thermionic emission etc.

Objective Questions

1. The S.I. Unit of entropy is :
(a) Joule/sec
(b) Joule/kelvin
(c) J-kelvin
(d) Joule-sec

2. The unit of work is :
(a) Joule (b) Newton (c) Watt (d) Dyne
[RRB T. C. 2005]

3. Parsec is the unit of :
(a) distance
(b) magnetic force
(c) shining of light
(d) time *[UPPCS (Pre) 1997]*

4. Light year is the unit of :
   (a) distance (b) time
   (c) intensity of light (d) mass [RRB ASM/C.C. 2005]
5. Which of the following is not the unit of time ?
   (a) leap year (b) lunar month (c) light year (d) None of these [RRB C.C. 2003]
6. Which of the following is not matched ?
   (a) Decibel—unit of sound (b) Horse power—unit of power
   (c) Nautical mile—unit of distance
   (d) Celsius—unit of heat [UPPCS (Pre) 2001]
7. The unit of magnetic flux is :
   (a) weber (b) weber/meter
   (c) weber-ampere (d) weber-sec
8. The S.I. unit of the Young's modulus of elasticity is :
   (a) dyne/cm. (b) newton/meter
   (c) newton/meter^2 (d) newton-sec [RRB TC 2005]
9. Which of the following is a vector quantity ?
   (a) energy (b) momentum
   (c) moment of inertia (d) all of these
10. An artificial satellite orbiting around the earth does not fall down. This is so because the attraction of the earth :
    (a) does not exist at such distance
    (b) is neutralized by the attraction of the moon
    (c) provides the necessary speed for its steady motion
    (d) provides the necessary acceleration for its motion [CSAT 2011]
11. The electric current density is :
    (a) a vector quantity (b) a scalar quantity
    (c) both (d) None
12. The surface of a lake is frozen in severe winter, but the water at its bottom is still liquid. What is the reason ?
    (a) ice is a bad conductor of heat
    (b) since the surface of the lake is at the same temperature as the air, no heat is lost
    (c) the density of water is maximum at 4°C.
    (d) none of the statements (a), (b) and (c) given above are correct. [CSAT (Pre) 2011]
13. Lumen is the unit of :
    (a) Luminous intensity (b) Luminous flux
    (c) Both (d) None [RRB ASM/GG 2004]
14. Candela is the unit of :
    (a) Luminous flux (b) Luminous effect
    (c) Luminous pressure (d) Luminous intensity [RRB ASM/CC 2004]
15. Which one of the following pair doesn't have the same dimension ?
    (a) force and pressure (b) work and energy
    (c) impulse and momentum (d) pressure and stress [RRB TC 2002]

16. The physical quantity obtained by the division of linear momentum of a body to its velocity is :
(a) velocity (b) acceleration (c) mass (d) force
[BPSC (Pre) 2002]

17. The bodies executing free falling motion have :
(a) equal momentum (b) equal velocity
(c) equal acceleration (d) equal force *[RRB TC/CC 2002]*

18. The increasing amount of carbon dioxide in the air is slowly raising the temperature of the atmosphere because it absorbs?
(a) the water vapour or the air and retains its heat
(b) the ultraviolet part of the solar radiation
(c) all the solar radiation
(d) the infrared part of the solar radiation *[CSAT, 2012]*

19. Rocket operates (works) on the principle of :
(a) Energy conservation (b) Bernoulli's theorem
(c) Avogadro's concept (d) Momentum conservation
[RRB Assitt. Driver 2003]

20. The blackboard seems black because it :
(a) reflects every colour (b) does not reflect any colour
(c) absorbs black colour (d) reflects black colour *[CDS, 2011]*

21. A cricket player catches a fast coming ball by pulling his hands back because :
(a) the ball can come to a position of rest
(b) the ball can be accelerated (c) the ball can exert a larger force
(d) the ball can exert a lesser force *[RRB Metro Rail 2002]*

22. Force is the product of :
(a) mass and velocity (b) mass and acceleration
(c) weight and velocity (d) weight and acceleration
[BPSC (Pre) 2002]

23. The weight of a human body is :
(a) same at every places on the earth's surface
(b) maximum at the poles (c) maximum at the equator
(d) more on the mountains than the plains *[RRB 2006]*

24. If the weight of a man is 600 N on the earth, then his weight on the moon will be :
(a) 6000 N (b) 60 N (c) 1000 N (d) 100 N
[RRB Metro Rail 2002]

25. If the weight of an object on the earth's surface is 29.4 N then the mass of the object would be :
(a) 2 kg (b) 3 kg (c) 4 kg (d) 29.4 kg
[RRB TC 2004]

26. A man (astronaut) can apply a more longer jump on the moon's surface than the earth's surface, because :
(a) he is weightless on the moon
(b) there exists no atmosphere on the moon
(c) the gravitational pull on the moon is lesser than that of the earth's surface
(d) the moon is smaller than the sun *[RRB CC 2003]*

27. The weight of an object of mass 1 kg can be expressed as :
(a) 1 N (b) 10 N (c) 9.8 N (d) 9 N
[RRB TC/CC 2003]

28. The product of the moment of inertia and the angular acceleration is :
(a) force (b) torque
(c) work (d) angular momentum *[RRB 2003]*

29. A body is charged negatively. It implies that :
(a) it has lost some of its protons
(b) it has acquired some electrons from outside
(c) it has lost some of its electrons (d) none of the above *[CDS, 2011]*

30. A piece of ice is floating on the surface of the water kept in a beaker and when this piece melts then the level of the water in the beaker :
(a) will increase (b) will decrease
(c) will be same
(d) will firstly increase then it would decrease *[RRB ASM/GG 2004]*

31. Due to contraction of eyeball, a long sighted eye can see only :
(a) farther objects which is corrected by using convex lens
(b) farther objects which is corrected by using concave lens
(c) nearer objects which is corrected by using convex lens
(d) nearer objects which is corrected by using concave lens *[CDS, 2011]*

32. Why do you feel cool under a tree but not so under a tin shed on a sunny day?
(a) The greenness of the tree gives the cool feeling
(b) Photosynthesis absorbs heat
(c) The leaves convert water vapours into water which is a heat-absorbing process
(d) The leaves give out water which vaporizes absorbing some heat as latent heat *[CDS, 2011]*

33. Why an iron nail floats on mercury but sinks in water ?
(a) less chemical affinity of iron than mercury with water
(b) the weight of iron nail is more than water but less than mercury
(c) the density of iron is more than water but less than mercury
(d) None of these *[UPSC (Pre) 1994]*

34. Water has its maximum density at :
(a) 100°C (b) 4°C (c) 0°C (d) –4°C
[BPSC (Pre) 1998]

35. Which one among the following would expand the most on being heated ?
(a) Water (b) Alcohol (c) Glass (d) Air
[CDS 2011]

36. If two pieces of ice are mutually pressed to each other then these pieces stick because :
(a) at higher pressure the melting point of ice decreases
(b) at higher pressure the melting point of ice increases
(c) at higher pressure the melting point of ice firstly decreases and then increases
(d) there exists no relation between the pressure and melting point of the ice
[RRB ASM/GG 2004]

37. At higher altitudes water boils at the temperature lower than 100°C because :
(a) due to lesser atmospheric pressure boiling point of water lowers
(b) the gravitational pull is lesser here
(c) the winds on the mountains are stormy
(d) None of these *[UPPCS (Pre) 1994]*

38. The inside pressure of a soap bubble is :
(a) more than the atmospheric pressure
(b) less than the atmospheric pressure
(c) equal to the atmospheric pressure
(d) half of the atmospheric pressure *[UPPCS (Pre) 1995]*

39. The sudden downfall of the reading of barometer indicates that the weather :
(a) will be stable and calm (b) will be rainy
(c) will be stormy (d) will be cyclonic *[UPPCS 1996]*

40. In which of the following kinetic energy does not exist :
(a) fired bullet (b) flowing water
(c) imparted hammer (d) stretched bow
[RRB TC/CC 2002]

41. If a moving body doubles its velocity then the kinetic energy of the body will be :
(a) double (b) four times (c) same (d) three times
[RRB TC/CC 2001]

42. The cyclist (man) leans or bends himself around a turning because :
(a) speed of man and cycle should be the same, otherwise the cycle will skid
(b) he bends to locate the centre of gravity inside the base which prevents him from falling down
(c) he bends to exert pressure on the cycle's wheels to move on the curved track (path)
(d) he bends to cross the curved path speedily *[RRB ASM/GG 2004]*

43. Which of the following force is exerted by a cream separator machine of the milk :
(a) centrifugal force (b) centripetal force
(c) non-central force (d) external force *[RRB TC/CC 2005]*

44. When a stone piece is brought from the moon's surface to the earth then :
(a) its mass will change
(b) its weight will change but its mass would remain constant
(c) the weight and mass both will change
(d) neither mass nor weight will change *[BPSC (Pre) 2004]*

45. The person sitting in a lift or elevator will experience more :
(a) when the lift is accelerated downwards
(b) when the lift is accelerated upwards
(c) when it is coming downwards with equal velocity
(d) when it is going upwards with equal velocity *[UPPCS (Pre) 1990]*

46. The apparent weight of a person sitting in a lift is less than its real weight when the lift moves

(a) upwards with an acceleration
(b) downwards with an acceleration
(c) upwards with equal velocity
(d) downwards with equal velocity

[RRB TC 2004]

47. The time period of a pendulum watch :
(a) depends on the mass (b) depends on the length
(c) depends on the time (d) depends on the temperature

[BPSC (Pre) 2005]

48. The pendulum watches become slowed down in summer because :
(a) of longer summer day
(b) the weight of the pendulum is increased in the summer
(c) pendulum becomes elongated and correspondingly time is elongated at per unit oscillation
(d) of appearance of friction in the coils *[UPPCS (Pre) 1994]*

49. If the length of a simple pendulum is increased by 4% then its time period will be :
(a) increased by 3% (b) increased by 2%
(c) increased by 4% (d) None of these

[RRB ASM/GG 2004]

50. The ratio of the transverse deformation and the longitudinal deformation is called :
(a) Poisson ratio (b) Bulk modulus of elasticity
(c) Rigidity modulus of elasticity (d) Young's modulus of elasticity

[RRB Assist. driver 2003]

51. The raindrops are spherical due to :
(a) surface tension
(b) atmospheric friction of air molecules
(c) gravity of the spherical earth
(d) viscosity of the raindrops *[RRB GG 2003, UPPCS (Pre) 2005]*

52. If a ship moves from fresh water into seawater, it will —
(a) sink completely (b) sink a little bit
(c) rise a little higher (d) remain unaffected *[CDS, 2011]*

53. The unit of viscosity is :
(a) poise (b) pascal (c) poiseuille (d) none of these

[RRB ASM 2003]

54. The scientist associated with floatation is :
(a) Archemedes (b) Newton (c) Louis Pasteur (d) All of these

[RRB CC 2005]

55. Satellites used for tele-communication relay are kept in a geostationary orbit. A satellite is said to be in such an orbit when :
1. The orbit is geosynchronous
2. The orbit is circular
3. The orbit lies in the plane of the earth's equator
4. The orbit is at an altitude of 22,236 km

Select the correct answer using the codes given below :
(a) 1, 2 and 3 only (b) 1, 3 and 4 only
(c) 2 and 4 only (d) 1, 2, 3 and 4 all *[CSAT (Pre) 2011]*

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56. If a coin is to
then it rises
(a) 9.8 m

57. The freque
(a) 20 Hz
(c) 1 Hz –

58. The angul
(a) decre
(c) remai

59.

The velo
(a) unif
(b) unif
(c) nor
(d) nor

60. The vel
(a) 330

61. Sound
(a) tra
(c) tra
(d) lo

62. Ultras
(a) le
(c) m

63. Infras
(a) l
(c) l

64. The
(a)
(c)
(d)

65. The
(a)
(b)
(c)
(d)

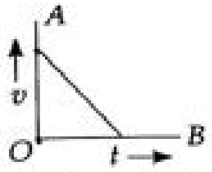
66. If th
wil

56. If a coin is tossed upwards from the ground with a velocity of 9.8 m/sec then it rises to a height :
(a) 9.8 m (b) 10 m (c) 4.9 m (d) 49 m
[BPSC (Pre) 2008]

57. The frequency of sound waves in the audible range is :
(a) 20 Hz — 20,000 Hz (b) 0.5 Hz — 5 Hz
(c) 1 Hz — 10 Hz (d) 20,000 Hz — 40,000 Hz
[RRB ASM/GG 2005]

58. The angular speed of a whirlwind in a tornado towards the centre
(a) decreases rapidly (b) increases
(c) remains constant (d) slowly becomes zero *[CDS 2011]*

59.



The velocity-time (v-t) graph shown above illustrates—
(a) uniform acceleration of an object
(b) uniform retardation of an object
(c) non-uniform acceleration of an object
(d) non-uniform retardation of an object *[CDS, 2011]*

60. The velocity of sound in the air (vacuum) is :
(a) 330 m/sec (b) 220 m/sec (c) 110 m/sec (d) 232 m/sec
[RRB Assistt. Driver 2008]

61. Sound is a :
(a) transverse mechanical wave (b) longitudinal mechanical wave
(c) transverse non-mechanical wave
(d) longitudinal non-mechanical wave

62. Ultrasonic wave has its frequency :
(a) less than 20 Hz (b) more than 20 Hz
(c) more than 20,000 Hz (d) 20 Hz — 20,000 Hz

63. Infrasonic wave has its frequency :
(a) less than 20 Hz (b) more than 20 Hz
(c) less than 20,000 Hz (d) more than 20,000 Hz

64. The noise of 100 db is assumed to be :
(a) a properly listened sound (b) an ordinary conversation
(c) a noise of the street
(d) a noise produced by the machine of a shop and listened at another neighbour's place *[IAS (Pre) 2000]*

65. The focal length of a convex lens is —
(a) the same for all colours
(b) shorter for blue light than for red✓
(c) shorter for red light than for blue *[CDS, 2011]*
(d) maximum for yellow light

66. If the door of a running refrigerator in a closed room is kept open, what will be the net effect on the room ?

(a) It will cool the room (b) It will heat the room

(c) It will make no difference on the average

(d) It will make the temperature go up and down [CDS, 2011]

67. Decibel is the unit of physical quantity used for :
(a) the speed of light (b) the intensity of heat
(c) the intensity of sound (d) the frequency of radiowaves
[SSC Graduate 2005]

68. The echo is produced by the sound waves due to :
(a) the reflection of sound (b) the scattering of sound
(c) the refraction of sound (d) None of these [RRB Driver 2002]

69. SONAR is frequently used by :
(a) Astronauts (b) Doctors (c) Engineers (d) Navigators
[UPPCS (Pre) 2004]

70. The pitch or frequency of the siren of a coming train appears to be increasing because of :
(a) Big-bang theory (b) Doppler's effect
(c) Charle's law (d) Archemedes's principle
[RRB ASM/GG 2005]

71. The normal temperature of the human body is :
(a) 280 K (b) 290 K (c) 300 K (d) 310 K
[IAS (Pre) 1995]

72. When a ball drops onto the floor it bounces. Why does it bounce ?
(a) Newton's third law implies that for every action (drop) there is a reaction (bounce)
(b) The floor exerts a force on the ball during the impact
(c) The floor is perfectly rigid
(d) The floor heats up on impact [CDS, 2011]

73. The lowest possible temperature is :
(a) –273°C (b) 0°C (c) –300°C (d) 1°C
[RRB TC 2003]

74. Which one among the following will you put into pure water in order to pass electric current through it ?
(a) Kerosene (b) Mustard oil (c) Lemon juice (d) Sugar
[CDS, 2011]

75. The temperature of the body of a healthy man is :
(a) 37°C (b) 37°F (c) 98.4°C (d) 98.4°K
[Uttrakhand PCS (Pre) 2005]

76. A refracting telescope consists of :
(a) one concave mirror and one convex lens
(b) two convex lenses of equal focal length
(c) two concave mirrors of different focal lengths
(d) two convex lenses of unequal focal lengths [NDA, 2012]

77. Which of the following is the best conductor of heat :
(a) mercury (b) water (c) leather (d) benzene
[UPPCS (Pre) 2005]

78. Garments keep us warm in the winter season because they :
(a) provide heat (b) do not radiate heat
(c) prevent air from coming in the contact of the body
(d) prevent heat of the body from going exterior [SSC Graduate 2004]

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79. A glass of water does not turn into ice as it reaches 0°C. It is because —
    (a) water does not solidify at 0°C
    (b) a certain amount of heat must be supplied to the glass of water so as to solidify
    (c) a certain amount of heat must be taken out from the glass of water so as to solidify
    (d) water solidifies at 0 K only [NDA, 2012]

80. Cryogenics are used in :
    (a) space journey, surgical works and magnetic resonance
    (b) surgical works, magnetic resonance and remote sencing
    (c) space journey, surgical works and remote sencing
    (d) space journey, magnetic resonance and remote sencing [IAS 1999]

81. The dew doesn't form in fast wind blowing during the night because:
    (a) the rate of vaporisation is fast
    (b) there is a lack of moisture in the wind
    (c) the temperature remains high (d) the sky is not clear [BPSC 1995]

82. The main power supply in India is 220V, whereas that in the US is at 110V. Which one among the following statements in this regard is correct
    (a) 110 V is safer but more expensive to maintain
    (b) 110 V is safer and cheaper to maintain
    (c) 110 V leads to lower power loss
    (d) 110 V works better at higher latitudes [NDA, 2012]

83. For a steel boat floating on a lake, the weight of the water displaced by the boat is?
    (a) less than the weight of the boat
    (b) more than the weight of the boat
    (c) equal to the weight of the part of the boat which is below the water level of the lake
    (d) equal to the weight of the boat [NDA, 2012]

84. The torque on a rectangular coil placed in a uniform magnetic field is large when the —
    (a) number of turns is large (b) number of turns is less
    (c) plane of the coil is perpendicular to the magnetic field
    (d) area of the coil is small [NDA, 2012]

85. Two metallic wires A and B are of same material and have equal length. If the cross-sectional area of B is double that of A, then which one among the following is the electrical resistance of B ?
    (a) Twice that of A (b) 4 times that of A
    (c) $\frac{1}{4}$ that of A (d) $\frac{1}{2}$ that of A [NDA, 2012]

86. Two thin convex lenses of focal lengths 4 cm and 8 cm are separated by a distance of 4 cm in air. The combination will have the focal length ?
    (a) 4 cm (b) 8 cm (c) 12 cm (d) 32 cm [NDA, 2012]

87. In the isothermal process which of the following remains constant :
    (a) temperature (b) heat (c) pressure (d) density

88. In the adiabatic process which of the following remains constant :
    (a) temperature (b) heat (c) pressure (d) volume

89. For the adiabatic process ideal gas equation is expressed as :
(a) pV^{γ} = constant
(b) $pV^{\gamma-1}$
(c) $p^{\gamma}V^{\gamma-1}$ = constant
(d) any of these

90. For the isothermal process ideal gas equation is expressed as :
(a) $PV = RT$
(b) $\frac{p}{V} = RT$
(c) $PV = RT^{\gamma}$
(d) $pV^{\gamma} = RT$

91. A fan produces a feeling of comfort during hot weather, because
(a) our body radiates more heat in air
(b) fan supplies cool air
(c) conductivity of air increases
(d) our perspiration evaporates rapidly [NDA, 2010]

92. Which one of the following statements is correct ?
(a) Only electrons reside inside the nucleus of an atom
(b) Both electrons and protons reside inside the nucleus of an atom
(c) Only neutrons reside inside the nucleus of an atom
(d) Both protons and neutrons can reside inside the nucleus of an atom [NDA, 2010]

93. Gases have two specific heat capacities :
(a) one at the constant volume and another at the constant pressure
(b) both at the constant volume
(c) both at the constant pressure
(d) none of these

94. The Carnot's engine takes heat :
(a) at constant temperature
(b) at constant volume
(c) at constant pressure
(d) none of these

95. The Otto engine takes heat :
(a) at constant temperature
(b) at constant volume
(c) at constant pressure
(d) none of these

96. Entropy is the measurement of :
(a) disorder parameter
(b) state of matter
(c) molecular configuration
(d) none of these

97. The light is a :
(a) transverse wave
(b) longitudinal wave
(c) both
(d) none [RRB ASM/GG 2004]

98. The ratio of velocity of X-rays to that of gamma rays
(a) is < 1
(b) is > 1
(c) is 1
(d) depends upon the ratio of their frequencies [NDA, 2010]

99. The velocity of light in vacuum or air is :
(a) 9×10^{2} m/sec
(b) 3×10^{11} m/sec
(c) 3×10^{8} m/sec
(d) 2×10^{4} m/sec [JPSC (Pre) 2003]

100. On raising the temperature of the medium velocity of light :
(a) increases
(b) decreases
(c) remains the same
(d) suddenly decreases [SSC 2004]

101. Which one of the following pairs of rays is electromagnetic in nature ?
(a) Beta rays and gamma rays
(b) Cathode rays and X-rays
(c) Alpha rays and beta rays
(d) X-rays and gamma rays [NDA, 2010]

102. The magnetic lines of force due to a bar magnet
(a) intersect inside the body of the magnet

(b) intersect at neutral points only
(c) intersect only at North and South poles
(d) cannot intersect at all

[NDA, 2010]

103. The specific resistance of a conducting wire depends upon —
(a) Length of the wire, area of cross-section of the wire and material of the wire
(b) Length of the wire and area of cross-section of the wire but not on the material of the wire
(c) Material of the wire only but neither on the length of the wire nor on the area of cross-section of the wire
(d) Length of the wire only but neither on the area of cross-section of the wire nor on the material of the wire

[NDA, 2010]

104. When X-rays are produced —
(a) heat is generated at the target (b) heat is absorbed at the target
(c) the temperature of the target remains constant
(d) brilliant light is seen at the target

[NDA, 2010]

105. Which one of the statements given below is not correct?
(a) A vertical plane passing through the axis of a freely suspended magnet is called the magnetic meridian
(b) A vertical plane passing through the axis of rotation of the Earth is called the geographical meridian
(c) The degree to which the magnetic field can penetrate a medium is known as the relative permeability of the medium
(d) The relative permeability is not a dimensionless quantity

[NDA, 2010]

106. If an object is placed at the centre of curvature of a concave mirror, the position of the image is
(a) at the principal focus
(b) between the principal focus and the centre of curvature
(c) at the centre of curvature (d) beyond the centre of curvature

[NDA, 2010]

107. The radius of curvature of a plane mirror
(a) is zero (b) is infinity
(c) can be anywhere between zero and infinity
(d) none of the above

[NDA, 2010]

108. The rainbow appears due to :
(a) reflection (b) refraction
(c) scattering (d) both reflection and refraction

[RRB CG 2005]

109. The sky appears blue :
(a) due to dispersion (b) due to refraction
(c) due to scattering (d) due to reflection [RRB 2004]

110. The diffusion of light in the atmosphere is due to :
(a) carbon dioxide (b) dust particle
(c) helium (d) water vapour [IAS (Pre) 2003]

111. A coin in a beaker filled with water appears raised. This phenomenon occurs because of the property of
(a) reflection of light (b) refraction of light
(c) total internal reflection light (d) interference of light [NDA 2010]

112. A ray of light falls on a transparent glass plate. A part of it is reflected and a part is refracted. The reflected and refracted rays can be perpendicular to each other for
(a) angle of incidence equal to 90°
(b) angle of incidence equal to zero
(c) only one angle of incidence
(d) more than one angle of incidence
[NDA, 2010]

113. A man with a dark skin, in comparison with a man with a white skin, will experience
(a) less heat and less cold (b) less heat and more cold
(c) more heat and less cold (d) more heat and more cold
[NDA, 2010]

114. Which one among the following denotes the smallest temperature ?
(a) 1° on the Celsius scale (b) 1° on the Kelvin scale
(c) 1° on the Fahrenheit scale (d) 1° on the Reaumur scale
[NDA, 2010]

115. For shaving which type of mirror is used :
(a) concave mirror (b) plane mirror
(c) convex mirror (d) none of these *[BPSC (Pre) 1999]*

116. When a body moves with simple harmonic motion, then the phase difference between the velocity and the acceleration is —
(a) 0° (b) 90° (c) 180° (d) 270°

117. An air bubble in water acts like a : *[NDA 2010]*
(a) convex mirror (b) convex lens
(c) concave mirror (d) concave lens *[UPPCS (Pre) 2002]*

118. A body is thrown vertically upwards and then falls back on the ground. Its potential energy is maximum —
(a) on the ground (b) at the maximum height
(c) during the return journey
(d) both on the ground and at the maximum height

119. If the power of a convex lens is +2 diopter then the focal length of the lens is : *[NDA, 2010]*
(a) 200 cm (b) 100 cm (c) 50 cm (d) 2 cm

120. The colour of an opaque object is due to that colour which : *[BPSC (Pre) 1996]*
(a) is absorbed (b) is not reflected
(c) is reflected (d) is scattered

121. Which one of the following pairs does ***not*** have the same dimension *[IAS (Pre) 1994]*
(a) Potential energy and kinetic energy
(b) Density and specific gravity (c) Focal length and height
(d) Gravitational force and frictional force

122. The best and the poorest conductors of heat are respectively ? *[NDA, 2010]*
(a) silver (Ag) and lead (Pb) (b) copper (Cu) and aluminium (Al)
(c) silver (Ag) and gold (Au) (d) copper (Cu) and gold (Au)
[NDA, 2010]

123. The three fundamental colours are :
(a) blue, yellow and red
(b) blue, green and red
(c) yellow, green and red
(d) blue, yellow and green
[MPPCS (Pre) 2004, RRB TC 2005]

124. A body is at rest on the surface of the earth. Which one among the following statements is correct regarding this ?
(a) No force is acting on the body
(b) Only weight of the body acts on it
(c) Net downward force is equal to the net upward force
(d) None of the above statements is correct
[NDA, 2010]

125. A pendulum beats faster than a standard pendulum. In order to bring it to the standard beat, the length of the pendulum is to be :
(a) reduced
(b) increased
(c) reduced and the mass of the bob increased
(d) reduced and also the mass of the bob reduced
[NDA, 2010]

126. Consider the following statements
1. Clear sky appears blue due to poor scattering of blue wavelength of visible light.
2. Red part of light shows more scattering than blue light in the atmosphere.
3. In the absence of atmosphere, there would be no scattering of light and sky will look black.

Which of the statement given above is/are correct ?
(a) 1 only
(b) 1 and 2 only
[✓ (c) 3 only]
(d) 1, 2 and 3
[CDS, 2010]

127. Hair of a shaving brush cling together when the brush is removed from water due to
(a) viscosity
(b) surface tension
(c) friction
(d) elasticity
[CDS, 2010]

128. Which one of the following statements is correct ?
(a) The angle of contact of water with glass is acute, while that of mercury with glass is obtuse
(b) The angle of contact of water with glass is obtuse, while that of mercury with glass is acute
(c) Both the angle of contact of water with glass and that of mercury with glass are acute
(d) None of the above
[CDS, 2010]

129. Who was the inventor of telescope ?
(a) Galileo
(b) Gutenberg
(c) Edison
(d) Graham Bell
[UPPCS (Pre) 1994]

130. Who was the inventor of radar ?
(a) Robert Watson
(b) Fleming
(c) Bush Wall
(d) Austin
[BPSC (Pre) 2008]

131. Human eyes are :
(a) converging lenses of variable focal length
(b) converging lenses of fixed focal length
(c) diverging lenses of variable focal length
(d) diverging lenses of fixed focal length

132. The function of heavy water in a nuclear reactor is to :
(a) slow down the speed of neutrons
(b) increase the speed of neutrons (c) cool down the reactor
(d) stop the nuclear reaction [CSAT (Pre) 2011]

133. What is the difference between a CFL and a LED lamp ?
1. To produce light, a CFL uses mercury vapour and phosphor while an LED lamp uses semiconductor material.
2. The average life span of a CFL is much longer than that of an LED lamp.
3. A CFL is less energy-efficient as compared to an LED lamp.

Which of the statements given above is/are correct ?
(a) 1 only (b) 2 and 3 only
(c) 1 and 3 only (d) 1, 2 and 3 [CSAT (Pre) 2011]

134. Examine the following statements :
1. Waves of low frequency are actually produced through the flute of lesser length.
2. Sound through the rocks only transmitted in the form of longitudinal elastic waves.

Which one of the following of the above statements is/are true :
(a) Only 1 (b) Only 2
(c) 1 and 2 both (d) Neither 1 nor 2 [IAS (Pre) 2007]

135. Consider the following statements :
1. A person with myopia can see distant objects distinctly but cannot see nearby objects clearly.
2. A person with hypermetropia cannot see distant objects clearly.
3. A person with presbyopia can see nearby objects without corrective glasses.

Which of the statements given above is/are *not* correct ?
(a) 1, 2 and 3 (b) 1 and 2 only
(c) 2 and 3 only (d) 3 only [CDS, 2010]

136. The phenomenon of interference can be obtained by :
(a) two independent sources of light
(b) two virtual and coherent sources of light
(c) any two sources whatever be the wavelength or frequency of the light waves
(d) None of these

137. The visible range of solar radiation is :
(a) 100 – 400 nm (b) 400 - 700 nm
(c) 740 - 10000 nm (d) none of these [BPSC (Pre) 2011]

138. The electrification in a body takes place due to :
(a) electron (b) positron (c) proton (d) neutron

139. The force acting on a particle executing simple harmonic motion is
(a) directly proportional to the displacement and is directed away from the mean position
(b) inversely proportional to the displacement and is directed towards the mean position
(c) directly proportional to the velocity and is directed away from the mean position

(d) inversely proportional to the velocity and is directed towards the mean position [CDS, 2010]

140. As the sunlight passes through the atmosphere, the rays are scattered by tiny particles of dust, pollen, soot and other minute particular matters present there. However, when we look up, the sky appears blue during mid-day, because

(a) blue light is scattered most (b) blue light is absorbed most

(c) blue light is reflected most

(d) ultraviolet and yellow component of sunlight combine [CDS 2010]

141. A passenger in a moving train tosses a five rupee coin. If the coin falls behind him, then the train must be moving with a uniform

(a) acceleration (b) deceleration

(c) speed (d) velocity [CDS, 2010]

142. Non-metals are bad conductors of electricity because :

(a) they lack free or mobile electrons

(b) they have light atoms

(c) they have high melting points (d) All of these

143. An object weights the maximum in :

(a) air (b) water (c) hydrogen (d) vacuum [JPSC (Pre) 2011]

144. The pressure exerted on the ground by a man is greatest

(a) when he lies down on the ground

(b) when he stands on the toes of one foot

(c) when he stands with both feet flat on the ground

(d) all of the above yield the same pressure [CDS, 2010]

145. Which one of the following is not needed in a nuclear fission reactor ?

(a) Moderator (b) Coolant

(c) Accelerator (d) Control device [CDS, 2010]

146. The shortest unit of length is :

(a) micron (b) nanometer

(c) angstrum (d) fermimeter [UPPCS (Pre) 2005]

147. An endoscope, used by doctors for examine the inside of a patient's stomach, works on the principle of :

(a) reflection of light (b) dispersion of light

(c) refraction of light (d) total internal reflection of light [JPSC (Pre) 2011]

148. If two conducting spheres are separately charged and then brought in contact :

(a) the total energy of the two spheres is conserved

(b) the total charge on the spheres is conserved

(c) both the total energy and charge are conserved

(d) the final potential is always the mean of the original potential of the two spheres [NDA, 2010]

149. The electrolyte in a car battery is :

(a) hydrochloric acid (b) sulphuric acid

(c) nitric acid (d) distilled water [BPSC (Pre) 1998]

150. Who was the inventor of voltaic cell :
(a) Benjamin Franklin (b) Thomas Edison
(c) Alizendro Voltas (d) Kirchhoff

151. Two pieces of metallic wire having equal length and equal volume placed in air have different resistances. The two wires must :
(a) have different cross sections (b) have different temperatures
(c) be of different materials (d) be of same density *[NDA, 2010]*

152. The process of zinc lamination (coating) on the iron is called :
(a) galvanization (b) electroplating (c) ionisation (d) None of these
[Jharkhand PCS (Pre) 2006]

153. The 'absolute zero of temperature' is
(a) the starting point of any scale of temperature
(b) the lowest temperature that is theoretically possible
(c) the temperature at which the vapours of all liquid substances freeze
(d) the temperature at which all substances exist in the vapour phase
[JPSC (Pre) 2011]

154. One astronomical unit is the average distance between :
(a) the Earth and the Sun (b) the Earth and the Moon
(c) the Jupiter and the Sun (d) the Pluto and the Sun
[JPSC (Pre) 2011]

155. Fish can survive inside a frozen lake, because
(a) fish are warm-blooded animals
(b) fish hibernate in ice
(c) water near the bottom does not freeze
(d) ice is a good conductor of heat *[JPSC (Pre) 2011]*

156. The S.I. unit of electric flux is :
(a) Nm^2/coul. (b) N coul/m^2 (c) Nm^2/coul.^{2} (d) None of these

157. A hollow metal ball carrying an electric charge produces no electric field at points ?
(a) outside the sphere (b) on its surface
(c) inside the sphere (d) only at the centre *[NDA, 2010]*

158. The filament of an electric bulb is made of :
(a) copper (b) iron (c) lead (d) tungsten
[RRB ASM/GG 2003, 2005, UPPCS (Pre) 2005]

159. The coil in a heater is made of ?
(a) Nichrome (b) Tungsten (c) Copper (d) Iron
[CDS, 2010]

160. Stephen Hawking is a :
(a) Pianist (b) Guitarist
(c) Scientist (d) American politician
[MPPCS (Pre) 2011]

161. The most familiar form of radiant energy in sunlight that causes tanning and sunburning of human skin, is called
(a) ultraviolet radiation (b) visible radiation
(c) infrared radiation (d) microwave radiation
[NDA, 2010]

162. If 10 bulbs each of 100 watt remain switched on for 1 hour daily, then the total electricity consumed everyday would be :
(a) 1 unit (b) 100 kWh (c) 10 unit (d) 10 kWh
[RRB ASM/GG 2004]

163. Who was the inventor of the lightning conductor ?
(a) Graham Bell (b) Lord Lister
(c) Benjamin Franklin (d) Einstein *[RRB ASM/GG 2004]*

164. A man is sitting on a rotating stool with his arms outstretched. If suddenly he folds his arm the angular velocity of the man would :
(a) increase (b) decrease
(c) become zero (d) remain constant *[NDA, 2010]*

165. Which of the following is a paramagnetic ?
(a) nickel (b) cobalt (c) chromium (d) copper
[UPPCS (Pre) 1990]

166. Which one of the following is diamagnetic :
(a) iron (b) bismith (c) nickel (d) cobalt
[IAS (Pre) 1998]

167. The magnetic effect of electric current was firstly observed by :
(a) Henry (b) Oersted (c) Faraday (d) Volt
[RRB ASM/GG 2005]

168. Who discovered the electric bulb ?
(a) Thomas Edison (b) Alexander Graham Bell
(c) William Cook (d) Terry Edison *[MPPCS (Pre) 2011]*

169. Who invented thermoscope an early form of thermometer ?
(a) Sir Christopher Wren (b) Charles F Richter
(c) Beno Gutenberg (d) Galileo *[MPPCS (Pre) 2011]*

170. Who gave the theory of gravity ?
(a) Charles Newton (b) Charles Babbage
(c) Issac Newton (d) John Adams *[MPPCS (Pre) 2011]*

171. Lenz's law is directly related to :
(a) energy conservation (b) mass conservation
(c) momentum conservation (d) none of these

172. Cloudy nights are warmer than cloud free nights because of ?
(a) green house effect (b) depletion in ozone layer
(c) infrared radiation (d) land surface radiation
[NDA 2010]

173. Who was the inventor of neutron ?
(a) Rutherford (b) Thomson (c) Chadwick (d) Newton
[UPPCS (Pre) 1995, 1996, Jhrkhand PCS (Pre) 2003]

174. For a particle revolving in a circular path, the acceleration of the particle is :
(a) along the tangent (b) along the radius
(c) zero *[NDA, 2010]*
(d) along the circumference of the circle

175. The size of the atomic nucleus is in the order of :
(a) 10^{-10} meter (b) 10^{-9} meter (c) 10^{-3} meter (d) 10^{-15} meter
[RRB ASM/GG 2004]

176. Who was the inventor of positron ?
(a) Rutherford (b) J.J. Thomson (c) Chadwick (d) Anderson [RRB ASM 2004]

177. The antiparticle of the electron is called :
(a) positron (b) neutrino (c) meson (d) antineutrino

178. Who was the inventor of neutrino ?
(a) Pauli (b) Fermi (c) Anderson (d) Yukawa

179. Microwave oven consumes less power due to :
(a) small frequency of radiation (b) short wavelength of radiation
(c) large frequency as well as wavelength of radiation
(d) small frequency as well as wavelength of radiation [NDA, 2010]

180. The sun is constantly radiating energy and yet is surface temperature is nearly constant at 6000°C. The constancy of solar temperature is due to :
(a) fission (b) black hole evaporation
(c) fusion (d) radioactivity [NDA, 2010]

181. Metal pipes used to carry water sometimes burst in the winter. This is because :
(a) water expands when it freezes
(b) metal contracts more than water
(c) outside of the pipe contracts more than inside
(d) metal expands more than water

182. The mesons are : [NDA, 2010]
(a) positively charged particles (b) negatively charged particles
(c) neutral (d) All of these

183. If three identical resistors each of resistance r are connected in parallel, then the equivalent resistance of the three resistors will be :
(a) $3/r$ (b) $r/3$ (c) $3r$ (d) r^3 [NDA 2010]

184. In summer season a fan gives us relaxation because :
(a) our body radiates more heat comparatively in air
(b) fan provides cold air
(c) the conductivity of air is increased
(d) our sweat vapourises very quickly

185. The ratio of the velocities of X-rays and γ-rays is : [NDA 2010]
(a) <1 (b) >1 (c) 1
(d) depends on the ratio of their frequencies [NDA 2010]

186. The nuclear force exists between :
(a) proton – proton (b) proton – neutron
(c) neutron – neutron (d) All of these

187. In the following rays pair which one is found to be naturally electro-magnetic ?
(a) β-rays and γ -rays (b) Cathode rays and X-rays
(c) α-rays and β-rays (d) X-rays and γ-rays [NDA 2010]

188. The nuclear force is :
(a) attractive and spin dependent
(b) attractive but spin independent
(c) repulsive and spin dependent (d) None of these

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189. The nucl
(a) 10^{-15} r
190. The magn
(a) cross
(b) only c
(c) only c
(d) do no
191. The nucle
(a) conse
(c) both
192. The phen
(a) Henr
(c) P. Cu
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197. The disin
called :
(a) Nucl
(c) Radi
198. The form
nuclei is
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(c) phot
199. Atom bo
(a) nucle
(c) both
200. Hydroge
(a) nucle
(c) both
201. Which ty
(a) Radic
(c) Infra

189.The nuclear force remains influential (effective) only upto :
(a) 10^{-15} m (b) 10^{-10} m (c) 10^{-5} m (d) 10^{-30} m

190.The magnetic lines of force produced through a bar magnet :
(a) cross inside the magnetic body
(b) only cross across the neutral points of the magnet
(c) only cross across the north pole and south pole
(d) do not cross anywhere in the magnet [NDA 2010]

191.The nuclear force is a :
(a) conservative force (b) non-conservative force
(c) both of these (d) none of these

192.The phenomenon of natural radioactivity was invented by :
(a) Henry Bacqurel (b) Rutherford
(c) P. Curie (d) None of these

193.The phenomenon of artificial radioactivity was invented by :
(a) Rutherford (b) Madam Curie (c) Newton (d) Dalton

194.The element on which the first artificial radioactive features were experimented :
(a) carbon (b) nitrogen (c) aluminium (d) None of these

195.The end element of every natural radioactive element is :
(a) carbon (b) silicon (c) bismuth (d) sulphur

196.On which of the following specific resistance of a conducting wire depends ?
(a) length of the wire, cross-sectional area of the wire and on the matter of the wire
(b) length of the wire, cross-sectional area of the wire but not on the matter of the wire
(c) only on the matter of the wire but not on the length of the wire and cross-sectional area of the wire
(d) only on the length of the wire and neither on the cross-sectional area of the wire nor on the matter of the wire [NDA 2010]

197.The disintegration process of a heavy nucleus into two lighter nuclei is called :
(a) Nuclear fusion (b) Nuclear fission
(c) Radioactive disintegration (d) Mass loss [RRB 2003]

198.The formation of a heavy nucleus by the combination of two lighter nuclei is :
(a) nuclear fission (b) nuclear fusion
(c) photoelectric effect (d) chemical reaction

199.Atom bomb is based upon the principle of :
(a) nuclear fusion (b) nuclear fission
(c) both of them (d) None of these [BPSC (Pre) 1994]

200.Hydrogen bomb is based upon the principle of :
(a) nuclear fusion (b) nuclear fission
(c) both of them (d) None of these

201.Which types of waves are utilized in the night visionary equipment ?
(a) Radio wave (b) Micro wave
(c) Infra red wave (d) None of these [IAS (Pre) 2009]

202. When X-rays are produced, then
(a) heat is produced on the target (b) heat is absorbed by the target
(c) temperature of the target is being constant
(d) a luminous light is to be seen on the target

203. The nuclear reactor is an example of : [NDA 2010]
(a) controlled fission (b) uncontrolled fission
(c) uncontrolled fusion (d) none of these

[RRB ASM/GG 2004]

204. The image of an object kept on the centre of curvature of a concave mirror is formed—
(a) at main focus
(b) between main focus and centre of curvature
(c) between pole and infinity (d) none of these

[NDA 2010]

205. Through a beaker containing water a coin kept inside it seems to be upwardly lifted because of—
(a) reflection of light (b) refraction of light
(c) total internal reflection of light (d) interference of light [NDA 2010]

206. Cobalt–60 is usually utilised is radiotherapy because of emission of :
(a) alpha rays (b) beta rays (c) gamma rays (d) X–rays

[IAS (Pre) 1999]

207. The fuel used in the breeder reactor is :
(a) thorium (b) uranium (c) deuterium (d) uranium-235

208. Atomic pile is used in :
(a) the production of nuclear fission
(b) the regulation of nuclear fission
(c) the regulation of thermonuclear fusion
(d) the atomic acceleration

209. Curie is the unit of : [SSC Graduate 2000]
(a) radioactivity (b) temperature (c) heat (d) energy

210. In the nuclear reactor, heavy water (D_2O) is used in the form of :
(a) moderator (b) coolant (c) castodian (d) controller

[RRB TC 2003]

211. The mass-energy relation is the conclusion of :
(a) quantum theory (b) general theory of relativity
(c) arial theory of energy (d) special theory of relativity

[SSC Graduate 2005]

212. The diode is a device which forces the current :
(a) to flow in one direction (b) to flow in both directions
(c) not to flow in any direction (d) None of these

213. The radar is utilised for : [RRB Assist. Driver 2003]
(a) the detection of solar radiation (b) the observation of planets
(c) the detection of aircrafts, ships etc and for the path indicators
(d) the detection of the intensity of the earthquakes

[RRB 2003]

214. A three dimensional photograph is prepared through :
(a) holography (b) photography
(c) photochromatic process (d) radiography

[UPPCS (Pre) 1990, CDS 2003]

215. Who was the inventor of cosmic rays ?
(a) Bruno Rosi (b) Victor Hess (c) Copernicus (d) Edvin Hebel

216. Who designed and fabricated the first prototype of the Radar :
(a) J.H. Van Tassel (b) W.C. Roentgen
(c) P.T. Phonsberth (d) Taylor and Young *[SSC 2000]*

217. Who was the inventor of gravitational laws ?
(a) Edison (b) Newton (c) Faraday (d) None of these
[RRB Assist. Driver 2003]

218. The Nobel prize started by Alfred Nobel, who had invented :
(a) Aircraft (b) Telephone (c) Safety lamp (d) Dynamite
[RRB Gorakhpur GG 2003]

219. Who was the inventor of television ?
(a) W. Ramsse (b) Robert Maless (c) J.L. Beyard (d) Johnson
[RRB CC 2003]

220. The Wright Brothers were the inventors of :
(a) telescope (b) radio (c) aeroplane (d) elevator
[RRB GC 2002]

221. X-rays was invented by :
(a) Hopkins (b) Roentgen (c) Marconi (d) Morse
[RRB GG 2003, UPPCS (Pre) 2005]

222. Who developed the atom bomb ?
(a) Bearnor Bon Bron (b) J. Robert Opan Heemar
(c) Adberd Taylor (d) Samual Cohen *[SSC 2002]*

223. Who developed the missile ?
(a) Bernor Bon Bron (b) J. Robert Opan Heemar
(c) Adberd Taylor (d) Samual Cohen *[SSC 2002]*

224. Who developed the hydrogen bomb ?
(a) Bernor Bon Bron (b) J. Robert Opan Heemar
(c) Adberd Taylor (d) Samual Cohen *[SSC 2002]*

225. Who was the inventor of electron microscope ?
(a) Nol & Ruska (b) Robert Koach
(c) Leewan Hock (d) C.P. Swansun *[SSC 2004]*

226. Who was the inventor of scooter ?
(a) Brad Shaw (b) Damlar (c) Einstein (d) Formich
[RRB ASM/GG 2005]

227. Relative humidity is measured by :
(a) Hydrometer (b) Hygrometer
(c) Lactometer (d) Potentiometer
[UPPCS (Pre) 1996, CPO SI 2003]

228. Which one of the following is used in measuring altitudes ?
(a) Barometer (b) Plane meter (c) Altimeter (d) Hydrometer
[RRB TC/CC 2002]

229. The device through which the intensity of the sunrays is measured :
(a) Astrometer (b) Chrescograph
(c) Barometer (d) Actiometer *[RRB GG 2003]*

230. Solar radiation is measured by :
(a) Pyrometer (b) Astrometer (c) Barometer (d) Manometer

231. The device through which the depth of the sea is measured by the us of sound wave :
(a) Radar (b) Sonar (c) Altimeter (d) Venturimete
[SSC Grad 2001]

232. The use of thermostat is :
(a) to measure temperature (b) to increase temperature
(c) to keep constant temperature
(d) to convert temperature into electricity *[MPPCS (Pre) 2004]*

233. The radiator of vehicles are used for :
(a) to heat the engine (b) to prevent thermal radiation
(c) to keep cool the engine (d) None of these

234. The device to record and to reproduce the detection of the recording is called :
(a) Audiophone (b) Detectophone (c) Gramophone (d) Microphone
[RRB ASM/GG 2004]

235. The law of floatation was invented by :
(a) Newton (b) Wright Brothers (c) Galileo (d) Archemedes
[RRB Disel Assit. 2002]

236. In isobaric and isochoric thermodynamical processes :
(a) pressure and volume remain constant
(b) volume and pressure remain constant
(c) pressure and temperature remain constant
(d) None of these

237. In the adiabatic process, which one of the following remains constant:
(a) heat (b) entropy (c) Both of these (d) None of these

238. In the ideal gas which type of energy is absent :
(a) Kinetic energy (b) Potential energy
(c) Both of these (d) None of these

239. The thermodynamical definition of an ideal gas implies that it is only temperature dependent and independent of its volume; it is the statement of :
(a) Joule's law (b) Joule-Kelvin's
(c) Wein's law (d) Stefan's law

240. In the porous plug experiment which one of the following physical quantity remains constant :
(a) enthalpy (b) entropy (c) Both of these (d) None of these

241. Which one of the following has maximum energy ?
(a) Violet light (b) Green light (c) Red light (d) Yellow light
[IAS (Pre) 2009]

242. The external work done is the maximum for the thermodynamical expansion of which one of the following process :
(a) adiabatic (b) isothermal (c) isobaric (d) isochoric

243. The energy radiance is maximum for the lowest wavelength; it is :
(a) Wein's law (b) Stefan's law (c) Planck's law (d) None of these

244. Temperature upto the order of 10^6 K is measured through :
(a) Thermometer (b) Pyrometer
(c) Thermocouple (d) None of these

245. Good absorbers are good emitters. This is the statement of :
(a) Kirchhoff's law
(b) Prevost's theory of heat exchange
(c) Stefan's law (d) Wein's law

246. On which one of the following thermometric scales only positive temperature is measured :
(a) thermodynamical scale (b) platinum resistance scale
(c) celsius scale (d) none of these

247. The Bernoulli's theorem is :
(a) energy conservation (b) mass conservation
(c) Both of these (d) None of these

248. In which one of the following is the speed of sound the maximum ?
(a) in the air of 0°C (b) in the air of 100°C
(c) in the water (d) in the wood *[IAS (Pre) 2006]*

249. If a tunnel is made along the diameter of the earth and a piece of stone is gently released then :
(a) it will execute SHM (b) it will execute periodic motion
(c) there is no specific motion (d) None of these

250. The time period of the revolution of the geostationary satellite around the earth is :
(a) equal to that of the earth (b) twice that of the earth
(c) equal to that of the moon (d) None of the above

251. The escape velocity of anybody on the earth's surface is equal to how many times the orbital velocity of the same body on the earth's surface :
(a) 2 times (b) $\sqrt{2}$ times
(c) $\sqrt{3}$ times (d) No any relations exists

252. If a body is revolving around the earth's orbit with its usual velocity, then what would be the minimum energy required to let it escape from the orbit :
(a) double of its orbiting energy (b) $\sqrt{2}$ of its orbiting energy
(c) triple of its orbiting energy (d) None of these

253. Newton's formula for the velocity of sound is wrong because of his consideration about the propagation of sound as :
(a) an isothermal process (b) an adiabatic process
(c) Both of these (d) None of these

254. Laplace made a correction in the basic formula of velocity of sound given by Newton and evaluated the correct value by considering that sound propagation is :
(a) an isothermal process (b) an adiabatic process
(c) both of these (d) none of these

255. In the formation of a stationary wave which one of the following process does not occur :
(a) energy transmits from one place to another
(b) energy remains confined within the space
(c) nodes and antinodes form consecutively
(d) None of these

256. Which one of the following is true about the stationary wave :
(a) it is formed by the superposition of two equal and opposite progressive waves
(b) it is formed by the superposition of two equal and of the direction plane progressive wave propagation
(c) any of the above
(d) None of these

257. Open organ pipes (air columns) are sweater than closed organ because :
(a) all harmonics are present in open organ pipes, while only harmonics are present in closed organ pipes
(b) all harmonics are present in closed organ pipes, while only harmonics are present in open organ pipes
(c) both of these
(d) Open organ pipes are convenient to blow than closed pipes

258. Which of the following effect is also called Edison effect :
(a) Photoelectric effect (b) Thermionic emission
(c) Both of these (d) None of these

259. Photoelectric effect occurs only in the light of :
(a) any wavelength (b) threshold wavelength
(c) any of these (d) None of these

260. The famous photoelectric effect was fully explained on the basis of :
(a) Quantum theory (b) Wave theory
(c) both of these (d) None of these

261. Which of the following indicates the lowest temperature ?
(a) on 1° C Celcius scale (b) on 1 K scale
(c) on 1° F scale (d) on 1° R scale

262. If a body executes SHM then the phase difference of the velocity acceleration of the body is—
(a) 0° (b) 90° (c) 180° (d) 270°
[NDA 20

263. Which one of the following pairs has not identical dimension ?
(a) potential energy and kinetic energy
(b) density and specific density (c) focal length and height
(d) gravitational force and frictional force
[NDA 20

264. At high altitudes, pressure cooker is preferable for cooking, because boiling point of water
(a) reduces due to higher atmospheric pressure
(b) reduces due to lower atmospheric pressure
(c) increases due to reduced gravitational force
(d) reduced due to increased ozone content in the atmosphere
[CDS 20

265. If an object having mass of 1 kg is subjected to a force of 1N it with ?
(a) a speed of 1 m/s (b) a speed of 1 km/s
(c) an acceleration of $10\ m/s^2$ (d) an acceleration of $1\ m/s^2$
[CDS 20

266. An athlete diving off a high springboard can perform a variety of exercises in the air before entering the water below. Which one of the following parameters will remain constant during the fall ?
(a) The athlete's linear momentum
(b) The athlete's moment of inertia
(c) The athlete's kinetic energy
(d) [✓ The athlete's angular momentum] *[CDS, 2010]*

267. The apparent weight of a steel sphere immersed in various liquids is measured using a spring balance. The greatest reading is obtained for the liquid
(a) having the smallest density (b) having the largest density
(c) in which the sphere was submerged deepest
(d) having the greatest volume *[CDS, 2010]*

268. A semiconductor has :
(a) negative temperature coefficient
(b) positive temperature coefficient
(c) both positive or negative temperature coefficient
(d) None of these

269. Two most popular semiconductors which are frequently used in solid state electronic devices are :
(a) Germenium and Silicon (b) Germenium and Carbon
(c) Silicon and Carbon (d) None of these

270. Which one of the following is the purest form of semiconductor :
(a) intrinsic (b) extrinsic
(c) both of these (d) None of these

271. In *p*-type of semiconductor the current mainly flows due to :
(a) electrons (b) holes
(c) both of these (d) none of these

272. In *n*-type of semiconductor the current mainly flows due to :
(a) electrons (b) holes
(c) both of these (d) none of these

273. A diffraction pattern is obtained using a beam of red light. Which one among the following will be the outcome if the red light is replaced by blue light ?
(a) Bands disappear
(b) Diffraction pattern becomes broader and further apart
(c) Diffraction pattern becomes narrower and crowded together
(d) No change *[CDS, 2010]*

274. The transistor acts like :
(a) an amplifier (b) an oscillator
(c) both of these (d) None of these

275. Which one of the following statements is true ?
(a) Temperatures differing by 25° on the Fahrenheit (F) scale must differ by 45° on the Celsius (C) scale
(b) 0°F corresponds to -32°C
(c) Temperatures which differ by 10° on the Celsius scale must differ by 18° on the Fahrenheit scale
(d) Water at 90°C is warmer than water at 202°F *[CDS, 2010]*

276. To operate through any laser it is common to achieve :
(a) population inversion (b) a meta excited state
(c) a super excited state (d) None of these

277. Which one of the following is marked on the common use fluorescent tubelight ?
(a) 220 K (b) 273 K (c) 6500 K (d) 9000 K

278. Which of the following is the mathematical statement of second law of thermodynamics :
(a) $dQ = Tds$ (b) $dS = TdQ$ (c) $TdU = dQ$ (d) None of these

279. The ratio of the specific heat capacities of a diatomic gas is :
(a) 1.33 (b) 1.44 (c) 1.66 (d) None of these

ANSWERS

1. (b) 2. (a) 3. (a) 4. (a) 5. (c) 6. (d) 7. (a) 8.
9. (b) 10. (d) 11. (a) 12. (c) 13. (b) 14. (d) 15. (a) 16.
17. (c) 18. (d) 19. (d) 20. (b) 21. (c) 22. (b) 23. (b) 24.
25. (b) 26. (c) 27. (c) 28. (b) 29. (b) 30. (c) 31. (c) 32.
33. (c) 34. (b) 35. (a) 36. (c) 37. (a) 38. (a) 39. (c) 40.
41. (b) 42. (b) 43. (a) 44. (b) 45. (b) 46. (b) 47. (b) 48.
49. (b) 50. (a) 51. (a) 52. (c) 53. (c) 54. (a) 55. (a) 56.
57. (a) 58. (b) 59. (b) 60. (a) 61. (b) 62. (c) 63. (a) 64.
65. (b) 66. (b) 67. (c) 68. (a) 69. (d) 70. (b) 71. (d) 72.
73. (a) 74. (d) 75. (a) 76. (d) 77. (a) 78. (c) 79. (c) 80.
81. (a) 82. (d) 83. (c) 84. (a) 85. (d) 86. (a) 87. (a) 88.
89. (a) 90. (a) 91. (d) 92. (d) 93. (a) 94. (a) 95. (b) 96.
97. (a) 98. (c) 99. (c) 100. (a) 101. (d) 102. (d) 103. (b) 104.
105. (c) 106. (b) 107. (b) 108. (d) 109. (c) 110. (b) 111. (b) 112.
113. (c) 114. (b) 115. (a) 116. (b) 117. (d) 118. (b) 119. (c) 120.
121. (b) 122. (a) 123. (b) 124. (b) 125. (a) 126. (c) 127. (b) 128.
129. (a) 130. (a) 131. (a) 132. (a) 133. (d) 134. (b) 135. (d) 136.
137. (b) 138. (a) 139. (b) 140. (a) 141. (d) 142. (a) 143. (d) 144.
145. (c) 146. (b) 147. (d) 148. (d) 149. (b) 150. (c) 151. (c) 152.
153. (b) 154. (a) 155. (c) 156. (a) 157. (c) 158. (d) 159. (a) 160.
161. (a) 162. (a) 163. (c) 164. (a) 165. (c) 166. (b) 167. (b) 168.
169. (b) 170. (c) 171. (a) 172. (d) 173. (c) 174. (b) 175. (d) 176.
177. (a) 178. (a) 179. (a) 180. (c) 181. (a) 182. (d) 183. (b) 184.
185. (c) 186. (d) 187. (d) 188. (a) 189. (a) 190. (d) 191. (a) 192.
193. (a) 194. (b) 195. (a) 196. (b) 197. (b) 198. (b) 199. (b) 200.
201. (c) 202. (a) 203. (a) 204. (c) 205. (b) 206. (d) 207. (a) 208.
209. (a) 210. (a) 211. (d) 212. (a) 213. (c) 214. (a) 215. (b) 216.
217. (b) 218. (d) 219. (c) 220. (c) 221. (b) 222. (d) 223. (a) 224.
225. (a) 226. (d) 227. (b) 228. (c) 229. (d) 230. (a) 231. (b) 232.
233. (c) 234. (c) 235. (d) 236. (a) 237. (c) 238. (b) 239. (a) 240.
241. (a) 242. (c) 243. (a) 244. (b) 245. (a) 246. (a) 247. (a) 248.
249. (a) 250. (a) 251. (b) 252. (a) 253. (a) 254. (b) 255. (a) 256.
257. (a) 258. (b) 259. (b) 260. (a) 261. (b) 262. (b) 263. (b) 264.
265. (d) 266. (d) 267. (c) 268. (a) 269. (a) 270. (a) 271. (b) 272.
273. (b) 274. (c) 275. (c) 276. (a) 277. (c) 278. (a) 279. (b)

★★★

02. Astronomy

(I) Development of Astronomy :

Astronomy : Natural science which deals with composition, motion and other additional features of the celestial bodies is called astronomy. There are various branches of astronomy like Astrophysics (Astronomy + physics), Astrodynamics, Astrobiology etc.

Universe or Cosmos : Our earth, space and every celestial body like the galaxy, sun, star, planet, comet etc. present in a system are collectively called universe or cosmos, while the study of these is called cosmology.

Our universe is made from billions of galaxies and every galaxy has billions stars. These stars may have their own family like our Solar system which has eight planets including earth as a member of the family.

Eminent astronomers and their outstanding contributions in brief :

Ptolemy's Geocentric theory : In 140 AD Ptolemy, a Greek astronomer, studied about the universe and propounded the geocentric (Earth + centric) theory. According to this theory the earth is confined at the centre of the universe, while the sun and other planets revolve around the earth.

Copernicus's Heliocentric Theory : A Polish astronomer Copernicus propounded the heliocentric (Sun + centric) theory in 1543 AD. According to this theory the sun is confined at the centre of the universe, while the earth and other planets revolve around the sun. Thus Copernicus was the first astronomer who propounded planetary motion around the sun.

Kepler's laws of planetary motion : J. Kepler (1571-1630) did rigorous study of the celestial bodies and their motion. He concluded that all the planets revolve around the sun in various elliptical paths.

Galileo : Galileo (1564-1642) who was a contemporary of Kepler confirmed and supported the ideology and the comprehensive view of Kepler. The beginning of modern astronomy come into existence in 1609, when the refracting telescope was invented by Galileo. Galileo was the astronomer who discovered four satellites of the planet Jupiter and sun spots in the sun. Galileo also asserted that the nearest star of the sun is proxima centuari.

Sir Isaac Newton : British physicist Newton (1642-1727) who invented reflecting telescope in 1668 also contributed about the planetary motion on the basis of the explained gravitational force-field theory. Later Newton's law of gravitation, which became the most fundamental and basic laws, was found to be equivalent to Kepler's laws.

Herschel : A British astronomer who studied the entire universe and the space through telescopes and concluded that our universe is not only confined upto solar system but it innumerable is just a very small part of our galaxy (a stellar body). There are unlimited galaxies and thus our universe is infinitely and endlessly extended.

Hubble's law of recession of galaxies : An American astronomer Edwin P. Hubble in 1925 told that in the universe like our galaxy (milkyway) there exist millions of galaxies. Later in 1929 Hubble on the basis of prediction and observation made, asserted that our galaxies are not at rest (static) but are recessing (outwardly going) and these are getting distant thus the speed of the galaxies are increasing. This is the law of recession of galaxies.

But Isac Asimov, an another astronomer did not agree on this view and he speculated that if the recession continues then their cession will be continued and then the speed of galaxies will be increased abruptly. Thus 125 billion light years later these galaxies will become invisible.

Doppler's shift : The recession of galaxies and the expansion of the universe are the two consequences which were detected and measured by optical Doppler's effect and it is called Doppler's shift. In other words, the phenomenon of *red shift* was accurately detected in the spectrum of light coming from the galaxies in the laboratory and all the wavelengths of coming light appeared to converge towards the wavelength of the red (200Å). This concludes that our observed galaxy is recessing outward from our earth. If there is a violet shift which is not to be detected be then our observed galaxy would seem to approaching our earth.

Georges Lemiatre's Big Bang Theory (Origin of Universe) : In 1920 a Belgium based astronomer Abbe Georges (Great + explosion) gave a theory according to which billions of years ago an extremely violent explosion occurred in which preliminary core substances photon and leptoquark gluon were scattered randomly. From these substances our galaxy originated and along with it a number of galaxies were also formed which still exist and are expanding. This concept of Big Bang theory is the most reliable, authentic and globally acceptable.

Pulsating or Oscillating Theory of Universe : This is a new evolution theory of the development of our universe. According to this theory our universe has been during expanding and contracting billions of years respectively. Dr. Alan Sunddas speculated that about 120 crore years ago an extremely violent explosion occurred and since then our universe has been expanding and this would continue until 290 crore years. That's ward gravitational force field will become sharply influential and the contraction in the universe would commence. This phenomenon is called inter-explosion and it will continue till 410 crore years. Ultimately when it would be extremely compressed and condensed once again an extremely violent explosion would occur and this cycle would continue.

(II) Celestial bodies : The heavenly bodies appearing in the sky like galaxies, stars, planet, satellites, comets etc. are called celestial bodies.

Galaxy : Galaxy is the largest group of the stars which are bounded by the appreciable gravitational forces and that's why a galaxy is also called continental universe. Also in a galaxy there are unlimited and endless stars which are not visible but a few of them appear at night in the clear sky in the form of arch. In every galaxy despite the presence of unlimited stars some dust particles and gases are also present. Our galaxy is made from 97% stars, 2% dust particles and 1% other gases.

Usually from the structural point of view there are three types of galaxy - Spiral, Elliptical and Irregular. Among all the galaxies 80% are spiral, 17% are elliptical and 3% are irregular.

Our galaxy - milky way is a spiral type of galaxy. After our galaxy (milky way) the nearest galaxy is Andromeda whose shape is also spiral.

Our Galaxy (Milky way) : Our solar system is a member of the galaxy that is called Milky way. This milky way is a member of a group of 24 galaxies which is called local group. Our galaxy (milky way) appears very fascinating like a river of flowing light in the sky but in reality it is composed of billion of twinkling stars.

Constellation : Usually there are countless stars in the sky and most of them are not distinctly visible, but a few of them are a group of extremely shining stars which have some specific shapes and sizes. These are composed of a special group of stars and it is called constellation.

There are various constellations which exist in our galaxy like Ursa Major-Great Bear, Ursa Minor-Little Bear, Orion-Great Hunter, Draeo-Dragon, Cygnus-Swan, Hercules, Hydra, Centaurus etc. Until now 89 constellations have been detected and identified and the largest among these is Centaurus in which there are 94 stars. The Constellation Hydra has nearly 68 stars.

Stars : The stars are those celestial bodies which have their own light and shine with it e.g. like the sun which is a star. Most of the stars are composed of 70% H_2, 28% He, 1.5% carbon, N_2 and Ne and 0.5% Fe and others by weight. The stars always exist in group and rares are isolated. There are 33% binary stars, about 42% stars are found to be in group, there are three stars in alpha century and six stars in caster. The stars have various life spans, some of these are adults, some are of moderate life and rest are in mortal stage. Thus stars originate, emit energy and develop theirself in a mature (adult) stage and ultimately die.

Origin & Evolution of a star : H_2 and *He* gases in the galaxy compressed in the condensed form begin the life cycle of a star which ultimately transform into tiny oort clouds. These clouds start to shrink or compress due to their own gravitational pull and a rigorous inner mechanism starts to activate and consequently this gaseous cloud is converted into star. This contracting condensed gaseous cloud is called proto star.

Due to the contraction in proto star the number of collisions among the atoms of gaseous cloud largely increases and consequently temperature is abruptly raised. The process of contraction in a star continues for approximately about one billion years and internal temperature is extremely increased. Thus at this temperature a thermonuclear process starts and the fusion nuclear reaction takes place in H_2 nucleus which transforms it into He. Ultimately the internal temperature and pressure are extremely increased.

Final stage of a star's life : Whenever a H_2 nuclei transforms into He by the nuclear fusion process and due to lack of H_2 in the stars their outer surface starts to expand which is the basic characteristic to end the star and ultimately star becomes red, called Red Giant. There is a possibility and speculation that our star (the sun) would be converted into red giant in the next 5 billion years.

After achieving the red giant position, stars either transform into White Dwarf stars or into Neutron stars. If the initial mass of the stars is equivalent to the mass of the sun, then these stars are called white dwarf stars, while if the initial mass of the stars is too large than that of sun, then these stars are called neutron stars. Thus we conclude that the transformation of red giants (giant stars) totally depends on its mass.

White dwarf stars : At this position external shell of the red giant starts to expand and simply disappears and only the core (central part of the star) is left which remains in the position of regular contraction. Due to contraction the internal temperature of such a star is extremely enhanced. That's why nuclear fusion occurs in the helium nucleus. Consequently due to the release of tremendous amount of fusion energy, the central core begins to shine like white dwarf stars and shining continues until the entire helium is not to be used up. Thus after exhausting helium inside it completely the star becomes black dwarf star and ultimately due to a substance of extreme density these disappear inside the intense space. Nearly 90% stars end and complete their life cycle in this way.

Neutron stars : At this position the external shell of the stars due to a massive contraction become violent and thereby a violent explosion by the tremendous deformed energy takes place and ultimately the shell is destroyed. Consequently the sky is twinkled by the dazzling and powerful light. Such explosions are called *Nova* or *Supernova*.

During the supernova explosion the gaseous cloud is deformed sharply in the space and these gases are used as the basic constituents (raw materials) for the new star. After the supernova explosion only the central core of the star survives and it contracts continuously. The large gravitational pull compresses the core and enhances the density of the substance abruptly. An extremely condensed substance is called neutron star because this is composed of neutrons. The life span of the neutron stars also depends on the mass and in heavy neutron stars the excess amount of masses converge at a point and such substance of an extreme condensed density is called black hole. A very small quantity of material of the black hole is equivalent to several tonnes. The gravitational force field of black hole is so sharp and strong that no substance, not even light, can escape, that's why *black hole* is not visible. The black hole is like a lake of infinite depth in the space. Black hole neither transmits any radiation nor reflects any other radiation but only absorbs all the incident radiations. That's why it is very difficult to identify (detect) a black hole.

Classification of stars : The classification of stars depends on various physical parameters like brightness, spectrum, temperature, shape, size etc.

On the basis of the brightness, stars can be classified into three main groups-

(i) Sharp bright stars (ii) Moderate bright stars
(iii) Less bright stars.

Our sun has been kept in the group of moderate bright group.

Also the life span of stars depends upon their masses and brightness and the star which is the brightest has shorter life time and vice-versa. On the basis of spectrum, stars can be classified into seven groups : O, B, A, F, G, K and M, in the decreasing order of the temperature. Our sun is a G type of star and the wavelength of the most sharp light is 550 nm.

The pole star and Bernard star are two other famous stars. The pole star always shines in north direction and is confined always at the upper part of north pole and that's why it always appears in the same direction. The pole star is a member of Ursa Minor-Little Bear star group.

The colour of the star is the indicator of its temperature. All distances of stars are measured in light years. 1 light year = 9.46×10^{15} metre.

Distance of the nearest stars from the earth

Star	Distance from the earth (In light years)
Sun (Nearest star)	Very small than one light year
Proxima centauri (After sun the near most)	4.22 light year.
Alpha centauri (After sun, proxima centauri near most)	4.35 light year.
Sirus (the most bright star)	8.60 light year.

(III) Solar System : The group of various celestial bodies like planets, satellites, asteroids, comets, meteors etc. revolving around the sun is called solar system. The sun is the father of the solar system whose mass alone is 99.97% and the entire celestial bodies have only 0.03% mass. Also in total mass of the celestial bodies two giant planets Jupiter and Saturn have 92% mass.

Planets do not have their own light but these planets lighten (shine) with the reflected light of the sun which they receive. The reflection of the light from various planets depend upon the atmospheric content and its nature. The celestial bodies which have no atmosphere and whose activity of reflection is very small (negligible) do not shine. The moon has no atmosphere, that's why it doesn't shine. All planets revolve around the sun in elliptical paths.

Only two planets Venus and Uranus revolve around the sun from east to west (clockwise), while other planets revolve from west to east (anti clockwise). Gravitational forces act and operate between the sun and planet due to which planets revolve around it, otherwise these planets undergo tangentially to the outer space. The north pole of the earth allocates the north direction of the entire solar system. Normally all planets revolve by the axial inclination around the sun.

The planets may be classified into two groups :

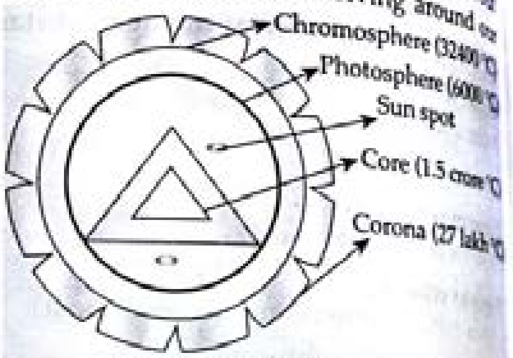
(i) Inner planets or Terrestrial planets : Under inner planets are Mercury, Venus, Earth and Mars have been which are comparatively smaller and denser. Among all the inner planets our earth is the largest and condensed.

All the inner planets are made from rocks and metals and resemble the earth that's why these are also called *terrestrial planets.*

(ii) Outer planets or Jovean planets : Under outer planets Jupiter, Saturn, Uranus and Neptune have been kept which are comparatively larger and less denser, form a larger satellite family. Outer planets are basically made up of He, NH_3 and CH_4. These planets are also called Jovean (Jove-Greek letter which implies like Jupiter) planets.

Sun

The sun is the heart spot of the solar system which is the source of energy of all organisms of the earth. Our galaxy-milky way is about 32000 light years distant from the sun. The sun is revolving around our galaxy milky way at a speed of 250 km / second. The period of revolution of the sun around the centre of our galaxy milky way is 25 *crore* years. This is called *cosmos year.* The sun is basically a gaseous system of body and these gases have different speeds at different parts. The central part of the sun rotate in 25 days, while polar part in 35 days.



Structure of Sun

The sun has been assumed to be made from the following layers :

(i) Core : The innermost layer of the sun is called core. It is basically a nuclear bath from where a tremendous amount of energy is generated and like other stars our sun has been also composed of hydrogen. By the process of nuclear fusion (thermo nuclear phenomenon) hydrogen nuclei are fused and transformed into helium nuclei and consequently a large amount of nuclear energy is released. This energy from the central part (core) reaches to the outer space through the radiation zone, convective layer and photosphere.

(ii) Convective layer : The layer just above the core is called convective layer and the energy generated by the core in this layer is convected.

(iii) Photosphere : The outer layer of the sun which is visible is called photosphere and from this layer the radiation of the light occurs. Also from this layer the solar diameter is determined (evaluated).

The solar atmosphere : The solar atmosphere also has various layers like chromosphere, corona etc.

(i) Chromosphere : Upper layer of the photosphere is vacuum which is called chromosphere and this is composed through H_2 gas. At the time of full solar eclipse chromosphere appears as a bright pink flash.

(ii) Corona : Behind the layer of chromosphere there is an outer part of the solar atmosphere called corona. The corona spreads to a far extent in the space which can emit X-rays. This part of the solar atmosphere is also normally seen during the occurrence of the solar eclipse. Whenever the solar eclipse appears then photosphere is completely covered or becomes invisible and corona seems to be visible. But at another occasion due to the scattering of light corona does not appear to be visible.

Sun spots : On the surface of the sun the burning of gases inside it makes some hollow space called sun spot whose temperature is about 1500°C less than that of the surrounding surface, that's why it is spotty. The sun spots remain visible from one-two days to two-three months. Whenever the sun spots appear then magnetic storms are produced on the earth's surface. Due to these magnetic storms the electrical appliances like radio, television, electric motors etc become noisy and bulky, the direction of the magnetic needle (compass) changes abruptly and boat puller, steemer puller become confused and misdirected. The complete cycle of sun spots is of 22 years which is called sun spots cycle in which upto 11 years spots increase, while in the remaining rest 11 years spots decrease. Due to complete sun spots cycle, magnetic regions in the solar atmosphere change.

Sun : Important facts

Time of revolution	25 crore years (rotate with average speed of 250 km/second on a circular path)
Time of rotation	25 days - central part of the sun; 35 days- polar part of the sun.
Diameter	13 lakhs 92 thousands km. (about 14 lakh km.) (110 times of earth's diameter)
Relative mass (mass of the earth = 1)	3,32,776 (3 lakhs times than the mass of the earth.)
Density	1.41 g/cm^3.
Core Temperature	1,50,00,000°C.
Chemical composition	H_2 (71%), *He* (26.5%), other elements (2.5%)
Life time	about 10 billion years (10^{10} years)

Three categories of the celestial bodies : For the categorization of the celestial bodies a consensus was made in the conference of International Astronomical Union - *IAU* (established in 1919) held at Prague in August 2006. Here three categories of the celestial bodies were composed and accepted as below ;

I. Conventional planets : Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus and Neptune.

II. Dwarf planets or plutons : Pluto, Cheron, Ceres, Xena (2003 *UB* 313)

III. Small celestial bodies : asteroids, comets, meteors, satellites and other very little celestial bodies.

I. Conventional planets : According to the new definition and perception adopted by various astronomers of *IAU*, the conventional planets are those celestial bodies which fulfil the following conditions—

(i) Rotate around the sun (ii) Have sufficient masses and by virtue of these gravitational pull becomes so dominant that the shape of the bodies are assumed (considered) to be spherical. (iii) Do not intersect the revolving orbits of the another celestial body.

On the basis of the above postulates the planet Pluto has been discarded from the category of conventional planets at Prague summit of *IAU* held in August 2006. Consequently the total number of planets of our solar system is reduced by one and it has now become 8, while earlier it was 9. Now Pluto has been kept in the category of dwarf planets.

Prague summit : To define and interpret new definition of planets a Conference of International Astronomical Union - *IAU* was held in the capital city of the Czec republic Prague from 15-24 August 2006, where more than 2500 astronomers of nearly 75 countries participated. The planet Pluto due to its very small size and being too far from the sun was expelled (abandoned) from the category of conventional planets. Now Pluto has been kept in the category of dwarf planets along with three celestial bodies Cheron, Ceres and Xena - 2003 *UB* 313. Although *US* based agency *NASA* has expressed an objectionable view in this regard.

Out of all conventional planets, we know something more or less from the primitive days at least of six planets - Mercury, Venus, Earth, Mars, Jupiter and Saturn. Two planets- Uranus and Neptune were discovered after the invention of telescopes. The planet Uranus was invented in 1781 by William Herschel, while the planet Neptune was invented in 1846 by John Galle.

Order of planets :

I. **According to the distance from the sun :** Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune.

II. **According to the distance from the earth :** Venus, Mars, Mercury, Jupiter, Saturn, Uranus, Neptune.

III. **According to the size :** Jupiter, Saturn, Uranus, Neptune, Earth, Venus, Mars, Mercury.

Mercury : This planet is the nearest to the sun and it is 5 crore 80 lakh km. distant from the sun. Now it has become the smallest planet of the solar system, since the planet Pluto has been expelled from the family of conventional planets. In size it is slightly greater than the moon (natural satellite of the earth). Its diameter is about 4900 km and it rotates around the sun in 88 days. It revolves in its elliptical orbit with the speed of 1,72 000 km/second. Due to this larger speed a counterbalance is maintained between it and the gravitational pull of the sun. It completes one revolution in 59 days. The mass of Mercury is 0.056 times more than that of the earth. The density of Mercury is 5.6 gm/cm^3. More density of Mercury is the indication of its composition with heavy elements. The core of Mercury planet is made of iron and its gravitational pull is 3/8th of the earth.

There is no atmosphere of Mercury. The day on Mercury is extremely hot while the night is chilling cold. One complete day is equivalent to 176 days of the earth. Mercury resembles the moon and on it there are large mountains and volcanoes. There is a caloris basin whose diameter is 1300 km and it is enclosed by the mountains of 2000 metre height. *The planet mercury has no satellite.*

Venus : This planet is the nearest to the sun after Mercury. The average distance of this planet from the sun is 10 crore km and its size and weight is nearly equal to that of the earth. That's why Venus is also called *Earth's Sister* and Earth's twin. It takes 243 days to make one complete revolution about its axis. Like Uranus it revolves from east to west. The mass of Venus is 0.815 times that of the earth. The density of Venus is 5.2 g/cm^3. This planet is extremely hot and like a blast furnace. That's why a situation of pressure cooker is found here. After the sun and the moon it (venus) is the brightest among all planets. All around it there is a condensed cloud of sulphuric acid from its surface upto 80 km height. These clouds reflect most the sun rays or radiation (97%) incident upon this planet. Most of the surfaces of this planet are covered by the spiralled plain in which some live volcanoes are to be found.

This planet is composed of 97% CO_2, 3% nitrogen, water vapour, some others elements etc. The atmospheric pressure of Venus is 90 times more than the atmospheric pressure of the earth. Normally due to the appearance in morning at eastern sky and the appearance in evening at western sky Venus is also called *Morning star* and *Evening star* respectively. *Like Mercury, Venus also has no satellite.*

Earth : The earth is located between *venus* and Mars and from the distance point of view it is the third planet. The average (mean) distance of the earth from the sun is 14 crores 95 lakhs 98 thousands 500 km. which is equivalent to 1 Astronomical Unit (1 A.U.). The nearest position of the earth from the sun is called perigee and this nearest distance (perihelion) is 14.73 crore km, while the most distant position of the earth from the sun is called apogee and this farthest distance (aphelian) is 15.2 crore km. *Light takes only 8 minutes 18 seconds (498 seconds) to come from the sun to the earth. According to size the earth is the fifth largest planet and the fourth smallest planet.* The average (mean) diameter of the earth is 12, 740 km. But if the equitorial and polar diameters are measured, then these are 12, 756 km and 12, 714 km respectively. Normally the shape of the earth is spherical but it is flattened at the poles and exposed outward at the equator. This special shape of the earth is called oblate spheroid / ellipsoid / geoid. The period of revolution of the earth around the sun is 365 days, 5 hours, 48 minutes 45.51 second or 365¼ days with the speed of 1, 07, 160 km / hr. The earth is inclined at 66½° from its orbit and it revolves in an elliptical orbit around the sun. Due to this revolution of the earth around the sun seasonal changes occur. If the earth stops to revolve around the sun, then in one half of the earth there will be a permanent season and in another half there will be another permanent season.

The earth rotates from west to east about its axis with the speed of 1610 km/hr. and its one complete rotation is completed in 23 hrs. 56 minute 4.091 seconds. The earth is inclined at 23° 26' 59" (about $23\frac{1}{2}^\circ$) of the latitude with its axis. Due to the rotation of the earth about its axis, the phenomen of day and night occur. If the earth stops to rotate about its axis, then half of the earth will always be in light, while another half will be in complete dark. The mass and density of the earth are 5.97×10^{24}kg and 5.52 gm/cm^3.

Internally the earth is composed of Sial (Silica + Aluminium), Sima (Silica + Magnesium), Nife (Nickel + Iron) etc. Due to moderate temperature, presence of abundant oxygen and water (71% area enclosed by water), the earth is the only planet of the solar system where the existence of life is to be found. The earth is also called *blue planet* because due to the tremendous amount of water it appears blue from the outer space.

Above from the earth's surface there is a complete enclosure of the atmosphere. The earth's atmosphere is mainly composed of 78.03% nitrogen, 20.99% oxygen 0.98% others gases (inert gases etc). Due to gravitational force of attraction the atmosphere is bound with the earth.

Mars : This is the fourth planet from the distance point of view in our solar system. The distance of Mars from the sun is 22 crore 80 lakh km and it (Mars) is the second smallest planet of the solar system. The diameter of this planet is 6800 km and it revolves around the sun in 686 days. As the planet is also inclined to its orbit, seasonal changes also occur here. There is a winter of six months and a summer of six months here. This planet takes 24.7 hours to rotate about its axis in one complete cycle. The mass of this planet is 0.107 times that of the earth, while its density is 3.95 g/cm³. The gravitational pull of this planet is only one third (1/3rd) of the earth. The surface of Mars is deserted and its colour due to the presence of iron oxide is red. That's why it is also called *Red planet*. On the surfaces of Mars larger deserts, volcanoes, mountains etc. are found. Here the mountain of the largest height *Nix Olympia* is located which is three times larger than Mount Everest. The largest volcano of this planet is *Alumps Mones* and here the channel is also to be found. One of the famous channels is Valles Marineris, whose length is 4000 km, width is 200 km and depth is 6 km. Also on the surfaces of this planet there are larger ditches, volcanoes, [illegible] etc, which confirm that a long time ago there was a free flow of water.

All around Mars there is a thin layer of atmosphere where atmospheric pressure is very small. The atmosphere is composed of 95% carbon dioxide and 4% other gases which include N_2, Ar and water vapour etc. Gases like H_2, O_2 and O_3 (Ozone) are also found in very small amount. In [illegible] Voyking space vehicle reached on its surface. It was firstly predicted and observed that there is no possibility of life on the planet Mars. Other space expeditions for Mars probe are— Pathfinder, Mars Odissi, Bigel-2 (2003), Spirit & Opporutiny (2004).

Phobos and Deimos are the only two satellites of Mars. The satellite Deimos is the smallest among all the satellites of the solar system.

Jupiter : This is the fifth planet from the sun according to distance. This planet is at a distance of 77 crore 80 lakh km from the sun. Jupiter is the *largest* planet of the solar system. The diameter of this planet is 1 lakh [illegible] thousands km and it takes 11.9 years to revolve around the sun. This planet takes 9.8 hours of the rotation about its axis. This is also the heaviest planet of the solar system. The mass of the planet Jupiter alone is 71% of the mass of all the planets. Its mass is 318 times the mass of the earth and its density is 1.31 g/cm³. The gravitational pull of Jupiter is 5 times that of the earth. Despite being the largest planet its speed is also fast. Due to this speed its polar regions have become thin. In fact Jupiter is made of gas and liquid and these are confined in a spherical enclosure in which no solid surface is found to exist. The planet Jupiter has light gases as its constituents and these are H_2, NH_3, CH_4, He etc. The temperature of its surface is 108°C, while the temperature of its inside region is 25000°C. Through Pioneer space vehicle expedition great red spots were detected. Later by another expedition Voyager -1 it was confirmed that these great red spots were violent cyclones confined behind the unrest clouds. Also here rings of dust particles and volcanoes were detected.

All around the surface of Jupiter an atmosphere of thick cover of thousands of kilometer were found. The atmosphere of Jupiter is mainly composed of H_2 and He, while in small amount NH_3 and CH_4 are also present. Jupiter radiates more thermal radiation than what it absorbs from the sun and this radiation is electromagnetic in nature but it lacks thermal energy. The atmospheric temperature of Jupiter is 125°C.

Jupiter has 17 satellites in which *Ganymede* is the *largest* and it is largest satellite among all in the solar system. The other satellites of Jupiter are – Europa, Aayo, Calisto, Almthica etc.

Saturn : This is the eighth planet from the sun according to distance and its distance from the sun is 142 crore 70 lakh. In size it is the second largest after Jupiter in the solar system. The diameter of Saturn is 1 lakh 20 thousands km, it revolves in 29.5 years around the sun, it rotates in 10.2 hours about its axis and completes one rotation. The mass of this planet is 95 times more than the earth, while its density is very small (0.70 gm/cm^3) and if it is kept in water it would start to float. Saturn has been composed basically from gases and liquids and there is a lack of solid in it. It is mainly composed through H_2 and He, but a small amount of NH_3, CH_4 etc are also present. The average temperature of Saturn is 139°C.

The atmosphere of Saturn is made through H_2 and *He* and it is colder than the atmosphere of Jupiter. The average atmospheric temperature of Saturn is 180°C. The specific characteristic of Saturn is that there are some rings all around it and it is nearly 10. The expedition of Voyager- 1 detected that these rings are the strips of thousands of spiral waves whose thickness is nearly 100 feet.

In the sky this planet resemble a yellow star and it is the only planet which can be seen through the naked eyes. Saturn has 23 satellites, largest among all the other planets of the solar system. The largest satellite of Saturn is Titan and it was discovered by Christian Huygenes. The satellite Titan is the only satellite of the solar system which has a dense atmosphere and its atmosphere has a substantial amount of N_2 gas. Thus, on the satellite Titan the possibility of a trace of life was detected but no evidence about its existence were given.

Other satellites of Saturn are Atlus, Mimas, Incleds, Tethis, Dayona, Ria, Hyperian, Foebe etc.

Uranus : This planet was firstly invented by William Herschel in 1781 and it is called first modern planet of the solar system.

It is the seventh planet from the sun according to distance and it is located at a distance of 286 crore 90 lakh km from the sun. This is the third largest planet of the solar system. Its diameter is 52,000 km, it revolves in 84 years around the sun and it is inclined at 90° from its axis. That's why it is the only planet which revolves from one pole to another around the sun in its orbit. Thus Uranus is also called *laying planet.* It covers one complete rotation in 10.8 hours about its axis. The mass of this Planet is 14.5 times the mass of the earth, its density is 1.21 g/cm^3 and its surface also lacks of solid. The temperature of its surface is 197°C.

The atmosphere of this planet is also dense in which Methane (CH_4) gas is the main constituent and that's why on looking through the telescope it looks green. Despite CH_4, H_2 and He are also to be found as the main constituents of the atmosphere. The average atmospheric temperature of it is 225°C. Like Saturn this planet also has some indistinct rings. These rings are sharply compressed and these are 9 in number. In these rings Alpha, Beta, Gamma, Delta, Episilion etc. are significant and relevant. There is a large magnetic field which exists around 40 lakh square miles.

There are 15 satellites of the planet Uranus in which Arial, Ambrial, Titania, Oberon, Miranda etc. are important.

Neptune : This planet was discovered by a German astronomer John Galle in 1846 and it is the eighth planet from the sun according to distance. It is 450 crore 5 lakh km from the sun and it is the fourth largest planet in the solar system. The mean diameter of Neptune is 49, 000 km. It takes 165 years to revolve around the sun and it is the planet which revolves in so long an interval around the sun. Neptune rotates about its axis in 15.8 hours and completes one rotation. The mass of this planet is 17.2 times that of the earth. The mean density of this planet is 1.67 g/cm^3, while this planet also lacks the surface of solid. The temperature of the surface of this planet is 193°C. It is the coldest planet among all (when the planet Pluto had lost its significance as a planet).

Also, Neptune has two satellites namely— Triton and Nereid.

II. Dwarf planets or Plutones : The astronomers of IAU called the second category of the celestial bodies as dwarf planets or plutones of the solar system. Plutones means— Pluto and other celestial bodies like it. In this group along with Pluto, others namely Cheron, Ceres, Xena - 2003 UB 313 were kept.

Pluto : The planet Pluto was firstly discovered by Claad Tambo in 1930 whenever it was located in the copper belt. Despite the lack of necessary scientific need of the definition of the planet although it was included in the group of planets. But in August 2006 at Prague summit of IAU a new definition was adopted for a planet and Pluto was expelled and discarded from the category of conventional planets. Now Pluto has been kept in the category of dwarf planets.

Pluto is 589 km distant from the sun and its diameter is 2300 km. Pluto revolves around the sun in 248 years, it revolves irregularly and its orbit intersects the orbit of Neptune. This planet rotates in 6.4 days and completes one rotation. The mass of Pluto is 0.002th part of the mass of the earth, while its density is 2.03 g/cm^3. Pluto is in fact composed of water and frozen ice of the methane (CH_4) in the spherical form. The temperature of the surface of Pluto is 220°C. It is an extremely cold dwarf planet.

Cheron : Earlier it (Cheron) was accepted as the only satellite of Pluto but at Prague Summit held in August 2006 by IAU it was placed in the category of dwarf planets. The diameter of Cheron is measured as 1192 km.

Ceres : Ceres was invented by an Italian astronomer Piyaji in 1801 and it is the largest among all the discovered asteroids. The diameter of Ceres is 936 km which is $\frac{1}{5}$th part of the diameter of mercury. According to the new definition of celestial bodies it has been kept in the category of dwarf planets.

Xena - 2003 *UB* 313 : According to the new definition adopted by IAU in 2006 at Prague Summit Xena - 2003 UB 313 is a dwarf planet. Xena-2003 UB 313 is nearly 1490 mile flattened and it is also called Eris (136199)

(III) Small celestial bodies : According to IAU it is the third category of celestial bodies under which asteroids, comets, meteors, satellites etc. have been kept.

Asteroids : These are those celestial bodies which have various shapes and sizes of rocky debris revolving around the sun and mainly moving between the orbits of Jupiter and Mars in the strip of 547 million km. In our universe there are nearly 40, 000 asteroids. The Cheron (asteroid) revolves around Saturn and Uranus. According to the astronomers the asteroids originate from the result of explosion of the planets. Thus, asteroids are the parts and pieces of the larger planets which later became apart. An asteroid namely *Four Vesta* can be seen through the naked eyes. Some others asteroids are Aten, Pallas, Hygeia etc.

Comets : The word 'comet' originates from Greek letter Aster Komates which implies a star of a very long hair. In comet very long hair is a tail which is like the hair flying in the open air. This tail is originated from a nucleus and it is the normal feature of a comet. But all the comets do not display this configuration. The tail of a comet is distinctly seen near the sun. The region (space) outer to the planet Pluto is the region of asteroids and after it dense outer space begin.

A comet is basically composed from ice and dust particles and collectively the basic constituents of the comet are ice, methane, ammonia, carbon dioxide, water etc in the state. In the ice some rocks are also frozen. The comet revolves around the sun in the elliptical orbit and it revolves in such a way that the expansion of the tail is always confined in the opposite direction of the sun. But the head of the comet is towards the sun. Usually its orbit is very long and that's why it appears at a very long interval of time. In primitive days it was assumed that comet never comes again but Edmund Halley proved that the comet appears at a very long interval of time. Halley's comet is a main comet which had appeared in 1986 and will now appear after 75.81 years (nearly 76 years) in 2062.

As the comet enters inside the solar system the covered ice of it starts to melt and the gases are formed which ultimately converges in the form of nucleus. The gas emitting from the sun is confined in the opposite direction of the sun which is spread up to far away behind the nucleus of the comet and is ultimately converted into the tail of the comet. This tail of the comet is spread out up to a far extent in the space. Thus whenever any comet appears to be visible, it enters into the solar system and only its long tail is visible. This long tail of the comet is oppositely directed to the sun and a toxic and dangerous chemical, Cayonosen (CN) is found on it.

In primitive days since no proper knowledge about the orbits of the comet was known, it was assumed as bad omen, but later with the development of astronomy this misconcept and superstition was abandoned.

Meteor : During night sometimes an extremely bright substance which is seen to appear falling downward very fastly and which is basically the part of celestial bodies is called *meteor.* In fact whenever some celestial bodies enter earth's atmosphere by the friction of air the temperature of these bodies are raised too much and ultimately they burn out. Thus, a meteor appears like a breaking star, that's why meteors are also called breaking stars. Some meteors do not burn properly (completely) in the atmosphere of the gravitational force-field and the unburnt part falls on the earth and these are called *Meteorites.*

Satellite : Those celestial bodies which revolve around the planets are called satellites. The satellite also has no light of its own and it revolves around the sun along with their respective planets. Like planets, satellites also revolve in elliptical orbits but these satellites are small in their sizes comparison to the planets.

In our solar system there are nearly 60 satellites in which Gaynmede is the largest and Deimos is the smallest.

Satellites of various planets

Planet	No. of satellites	Name of the main satellites
Earth	1	Moon
Mars	2	Phobos, Deimos
Jupiter	17	Europa, Aayo, Calisto, Gaynmede, Almthica etc. (biggest of solar system
Saturn	23	Titan, Atlus, Mimas, Tethis, Dayona, Rio, Hyperian, Foebe etc.
Uranus	15	Arial, Miranda, Ambrial, Titania, Oberon etc.
Neptune	2	Triton and Nercid

Satellite of the earth — Moon : The moon is the only natural satellite of the earth and it is the only satellite of the all planets of the solar system which is substantially larger than other satellites. Normally all the satellites have 1/8th part of the size of their respective planets, while moon has 1/4th diameter that of the earth. The gravitational force-field of the moon is 1/6th of the earth. The moon is the nearest celestial body of the earth and its distance from the earth is 382 thousands km. Also the nearest distance (perigee) of the moon from the earth is 364 thousands km, while the farthest distance (apogee) of the moon is 406 thousands km. The moon revolves all around the earth in 27.3 days (27 days, 7 hours, 43 minutes, 11.47 second) and in the same time it rotates about its axis and completes one rotation. Due to equal time period of revolution and rotation only single surface of the moon appears to be visible and this surface is only confined towards the sun. The rear (back) side of the moon always remains in dark where some specific regions are seen and called sea of tranquility and sea of showers. The mass of the moon is 0.012 times as that of the earth and its density is 3.4 gm/cm^3. The moon and the earth are made from same rocks, that's why it is predicted that the moon has originated from the earth and the moon is made from the broken part of the rocks of the earth. The colour of the soils made from the rocks of the moon is brown. There is no water on the moon. The waterless area (region) of the moon is called ocean of storms. The surface of the moon is not plane and uniform. The great mountain, larger plane and somewhere long depth ditches etc. are found. The most elevated place on the moon is Libnitz mountain which is located at the south pole of the moon and it is 35,000 feet high. Due to meteor falls or volcanic erruptions on the surface of the moon so many ditches have been made. The spots which are visible are suspected to have formed through the lava of the volcanoes and which has been transformed into great plain. Through the naked eyes the part of the moon which we look has bright and sharp strips. The brightest part of the moon are the regions of mountains and plateaus.

The temperature of the moon's surface is 100-130°C in the day and 170°C in the night. Due to a substantial gap between day and night temperature, atmosphere on the moon doesn't exist. Another reason for the explanation of the absence of atmosphere is that the value of the escape velocity of gaseous molecules of the atmospheric gases is very low (2.4 km/second) than the rms (root mean square) velocity of the gaseous molecules. Due to the absence of atmosphere on the moon no sound can be heard and also the sky from the moon's surface appears black. *The light from the moon to the earth's surface only reaches in 1.3 second.*

Objective Question

1. Who speculated that our universe is expanding ?
   (a) Newton (b) Edwin Hubble
   (c) Galilio (d) Copernicus
2. Who had propounded the planetary laws ?
   (a) Newton (b) Kepler (c) Galilio (d) Coupernicus
3. Who had proved first that our earth and another planets are revolving :
   (a) Aristotle (b) Galillio
   (c) Copernicus (d) Edwin Hubble
4. Which one of the following elements occur most abundantly in our universe ?
   (a) hydrogen (b) nitrogen (c) helium (d) oxygen
5. The stellar and solar source of energy is :
   (a) Nuclear fusion (b) Nuclear fission
   (c) electromagnetic induction (d) electromotive force
6. The device used to measure the diameters of stars and our galaxy (milky way) is called :
   (a) photometer (b) barometer
   (c) viscometer (d) interferometer

7. What is the difference between asteroids and comets ?
   1. Asteroids are small rocky planetoids, while comets are formed of frozen gases held together by rocky and metallic material.
   2. Asteroids are found mostly between the orbits Jupiter and Mars, while comets are found mostly between Venus and Mercury.
   3. Comets show a perceptible glowing tail, while asteroids do not.

   Which of the statements given above is/are correct ?
   (a) 1 and 2 only (b) 1 and 3 only
   (c) 3 only (d) 1, 2 and 3 *[CSAT -IAS (Pre) 2011]*

8. The planet which has the largest number of satellites is :
   (a) Saturn (b) Jupiter (c) Mars (d) Neptune

9. Which one of the following planet is also called morning star or evening star ?
   (a) Mercury (b) Venus (c) Mars (d) Saturn

10. The planet which completes one revolution in 88 days around the sun is :
    (a) Mercury (b) Venus (c) Mars (d) Saturn

11. The planet whose density is less than water and on keeping at the water surface it starts to float :
    (a) Mercury (b) Venus (c) Saturn (d) Mars

12. The jet aircrafts fly very easily and smoothly in the lower stratosphere. What could be the appropriate explanation ?
    1. There are no clouds or water vapour in the lower stratosphere.
    2. There is no vertical winds in the lower stratosphere

    Which of the statements given above is/are correct in this context ?
    (a) 1 only (b) 2 only
    (c) Both 1 and 2 (d) Neither 1 nor 2
    [CSAT -IAS (Pre) 2011]

13. The nearest star to the sun is :
    (a) beta centuary (b) alpha centuary
    (c) gamma centuary (d) proxima centuary

14. The planet Neptune was discovered by :
    (a) Galley (b) Galellio (c) Kepler (d) Newton

15. The nearest planet from the sun is :
    (a) Mercury (b) Venus (c) Earth (d) Mars

16. The smallest planet of the solar system is :
    (a) Saturn (b) Jupiter (c) Neptune (d) Uranus

17. Which of the following is not a planet of solar system ?
    (a) Mercury (b) Florida (c) Venus (d) Saturn
    [MPPCS (Pre) 2011]

18. Which one of the following star is the nearest to the earth ?
    (a) Pole Star (b) Comet (c) Sun (d) Asteroid

19. The small groups of planetory pieces which are confined and revolving between Mars and Jupiter are called :
    (a) Meteors (b) Comet
    (c) Celestial bodies (d) Asteroids

20. Halley's comet completes one revolution around the sun in :
    (a) 40 years (b) 46 years (c) 60 years (d) 76 years

21. Which year man firstly landed on the moon ?
(a) 1963 (b) 1965 (c) 1969 (d) 1972

22. From the space the sky appears to an astronaut :
(a) Blue (b) Red (c) White (d) Black

23. Which of the following is also known as red planet ?
(a) Mercury (b) Venus (c) Mars (d) Saturn

24. The earth revolves around the sun in :
(a) 360 days (b) 365 days (c) 365.25 days (d) 24 hrs

25. Paris based minor planet centre of International Astronomical Union (IAU) has given a new name to the planet Pluto which is :
(a) 134340 (b) 238380 (c) Iris (d) Nixe

26. The new name of the celestial body Xena–2003 UB 313 given by IAU is :
(a) Sires (b) Iris (c) Grabrili (d) Daysomia

27. Planet Saturn is :
(a) Cooler than Pluto (b) Cooler than Neptune
(c) Hotter than Neptune (d) Hotter than Jupiter
[MPPCS (Pre) 2011]

28. Who gave the first information regarding the Black Hole :
(a) Copernicus (b) Herman Bondy
(c) Rutherford (d) S. Chandrashekhar

29. What is the distance of the earth from the Sun ?
(a) 107.7 million km (b) 142.7 million km
(c) 146.6 million km (d) 149.6 million km
[MPPCS (Pre) 2011]

30. Which one of the following is also called Blue planet or Green planet :
(a) Mars (b) Earth (c) Venus (d) Saturn

31. The planet where there exists a situation like pressure cooker is :
(a) Jupiter (b) Mars (c) Venus (d) Mercury

32. If the radius of the earth is reduced by half, then the day-night on the earth would be of :
(a) 6 hrs (b) 12 hrs (c) 18 hrs (d) 36 hrs

33. The planet Pluto has been abondoned from the group of conventional planets and kept in the group of dwarf planets by a summit (conference) held in—
(a) Prague (b) Paris (c) London (d) Geneva

34. The planet nearest to the earth is :
(a) Mercury (b) Venus (c) Mars (d) Jupiter

35. The earth has the size among all the planets :
(a) fifth (b) third (c) fourth (d) seventh

36. The largest satellite of the planet Jupiter is :
(a) Gantmede (b) Uropa (c) Calisto (d) None of these

37. The largest satellite of the planet Saturn is :
(a) Atlas (b) Titan (c) Tethis (d) None of these

38. The stratosphere is said to be ideal for flying jet aircraft because :
(a) this layer is rich in ozone which reduces fuel consumption
(b) the temperature is constant and ideal for aircraft engine efficiency

(c) this layer is out of the firing range of anti aircraft guns
(d) of the absence of the clouds and other weather phenomena

[JPSC (Pre) 2011]

39. Who had invented the planet Uranus ?
(a) William Herschel (b) William John
(c) Max Dewar (d) None of these

40. The planet whose relevancy as a planet has been ended at Prague Summit of IAU is :
(a) Uranus (b) Pluto (c) Mars (d) Ceres

41. The back part of the moon is always calm and dark which is called :
(a) sea of tranquility (b) ocean of storms
(c) both of these (d) none of these

42. Which one of the following is the most elevated place on the moon's surface ?
(a) Libnitz mountain (b) Dream mountain
(c) Black mountain (d) None of these

43. The area of the moon's surface where there is no evidence of the of water is called :
(a) ocean of storms (b) areas of storms
(c) any of these (d) None of these

44. The sky appears black from the moon because of :
(a) lack of atmosphere (b) lack of cloud
(c) lack of oxygen and CO_2 (d) none of these

45. The value of escape velocity on the moon's surface is :
(a) 3.4 km/sec (b) 2.4 km/sec (c) 11.2 km/sec (d) 5.6 km/sec

46. On which one of the following planet, the maximum value of escape velocity is to be found
(a) Venus (b) Jupiter (c) Mars (d) Mercury

47. Which one of the following has minimum value of escape velocity on its surface ?
(a) Moon (b) Earth (c) Mars (d) Mercury

48. What portion of the moon is visible from the earth's surface ?
(a) 47% (b) 34% (c) 21% (d) 41%

49. At present how many planets are in existence ?
(a) 9 (b) 8 (c) 7 (d) None of these

50. An astronaut who landed or stepped down first on the surface of moon is:
(a) Neil Armstrong (b) Uri Gagarin
(c) Denial Pearl (d) None of these

Answers

1. (b) 2. (b) 3. (c) 4. (a) 5. (a) 6. (d) 7. (c) 8. (a)
9. (b) 10. (a) 11. (c) 12. (c) 13. (d) 14. (a) 15. (a) 16. (a)
17. (b) 18. (c) 19. (d) 20. (d) 21. (c) 22. (d) 23. (c) 24. (c)
25. (a) 26. (b) 27. (c) 28. (d) 29. (d) 30. (b) 31. (c) 32. (a)
33. (a) 34. (b) 35. (a) 36. (a) 37. (b) 38. (d) 39. (a) 40. (b)
41. (a) 42. (a) 43. (a) 44. (a) 45. (b) 46. (b) 47. (a) 48. (d)
49. (b) 50. (a)

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03. Computer

The word 'computer' originated from the English word *Compute* which implies to do calculation. Earlier computer was used for specially numerical calculations and simplifications, but later its working area was extended. Thus, we can say that computer is the system of electronic device through which various types of information are processed on the basis of a definite set of instructions called program and mathematical (numerical) and non-mathematical both types of information are processed.

Development of Computer : The first mechanical computer was developed and fabricated by Blaise Pascal in 1642 and it was called Pascalene. But in 1833, Charles Babbage first time conceived and devised an automatic calculator or computer. But even after 40 years hard core working he could not fabricate it ultimately. Although Charles Babbage is called the father of modern computer, the program of computer was first made available by Lady Ada Augsta. But in 1880 Herman Holereeth succeeded in designing a prototype of modern computer of Babbage model. Herman made an electronic tabulating machine based on punch cards which operates automatically. The discovery of punch card by Herman Toloreeth and a slight modification provided a special contribution in the development of computer. This modified punch card is frequently used in all the computers today.

In 1937, the first mechanical computer mark-I was fabricated by Howard Akeen. The computer science developed extensively during the Second World War (1939-1945) and after it all the main theories and principles of the modern computers were developed. In the field of numerical calculations the first revolution occurred in 1946, when J. P. Acert and John Mosheli invented the first electronic computer *ENIAC*-I (Electronic Numerical Integrator And Calculator) in the world. In this computer electronic valves like diode and triode valves were used as switches. The most outstanding contribution in the development of modern computer goes to John Wan Newmaan who brought the second revolution in the area of computer in 1951. He discovered *EDVAC* (Electronic Discrete Variable Automatic Computer) and utilised the stored program and the binary number system in the computer.

Computer Generations : Till now five various generations of the computers have been developed and the classification of the generations is basically due to the variant switching components.

Generation	Period	Main electronic components	Main computers
I. Gen.	1940-52	Electronic tube (vacuum tube)	EDSAC, EDVAC, UNIVAC.
II. Gen.	1952-64	Transistor	IBM-700, IBM-1401, IBM-1620, CDC-1604, CDC-3600, ATLAS, ICL-1901.

Generation	Period	Main electronic components	Main computers
III. Gen	1964-71	Integrated circuit (*IC*)	IBM-360, IBM-370, NCR-395, CDC 1700, ICL-2903
IV. Gen.	1971 to update	Largely Integrated circuit (*LIC*)	APPLE, DCM
V. Gen.	Research is going on	Optical fiber	

Types of computer : Computers are basically categorised on the basis of its sizes and working systems :

(A) Categorisation based on sizes : On the basis of size computes are of four types :

(i) Micro Computer : These are computers which are used by a single person, that's why these are also called Personal Computers (PCs). Such computers can be kept on a small table and these are used in offices, workshops and at various private organisations.

(ii) Mini Computer : These are the computers whose size and working power both are small and even twenty-twenty terminals operate at a time. The working power of such computers are 5 to 50 times greater than micro computers.

(iii) Main Frame Computer : These are the computers which are larger in size and fabricated in the steel frames. These computers have more memory power than earlier micro and mini computers. By a definite composition of time sharing and multi working power more than 100 persons can operate these computers at various terminals at a time.

(iv) Super Computer : This is the most powerful computer which can resolute very quickly to all those extremely complex processes and it has a very large storage capacity. Thus it is the most costly and the fastest working computer.

Developed super computers of the world

Name	Fabrication Institutions
Deep Blue	IBM Co. U.S.A.
Blue Gene	IBM Co. U.S.A.
Flo solver	NAL, Banglore
Multi Micro	IIs, Bangalore
Pram-10000	C-DAC, Pune

Super computers in India.

Name	Fabrication Institutions
Cosmos	Cambridge University, U.K.
Cray Kis	Cray K Research co; USA
Mach	IIT, Mumbai
Pace	DRDO
Anupam	BARC, Mumbai

In super computer 32 or 64 parallel circuits through a microprocessor are connected and on the informations or messages obtained one can work at a time. In it Magnetic Bubble Memories (MBM) or Charge Couple Devices (CCD) are used which have the highest storage capacity and due to these at a very small place the largest informations are compressed and processed in the compact form. A special type of air conditioning is also needed and these computers are used only when unlimited random informations appear in a very short span of time and all the concerned information and data are processed at a time.

Super computers are today frequently used at various occasions like in weather forecasting and in prediction of space research, satellite projection, in computerised nuclear test etc.

Quantum Computers : Despite the above computers a new breed of computer is in the advance and final stage through which in the fraction of a second extremely complex problems would be solved out. The scientists have claimed that the quantum computer can be so improved and micro modified that this computer can be made more efficient than human brain.

Through the quantum computer very complex problems like Fermat's last theorem can be solved very quickly which takes nearly 300 years by the conventional methods. The Reimann's hypothesis of mathematics which has been remained a unsolved problem can also be resoluted by it. All the important applications of the quantum mechanics have been used in the quantum computers. In quantum computers Q-Bit is used on behalf of the Binary Bits which is a complete composition of zero and one.

Types of computers (on the basis of size)

Name	Size	Storage capacity	CPU speed power	Examples/Utilities sector
Micro Computer	TV set	Upto 256 KB	1-10 MIPS	Personal Computer (PCs), Home computer, Educational computer, Electronic diary or Briefcase computer.
Mini Computer	Small table	256 KB-80MB	10-30 MIPS	Insurance company, Bank, Industry, Traffic etc.
Main frame computer	Big steel frame	10 MB-128 MB	30-100 MIPS	Aircraft services, Railway station.
Super Computer	Very larger size	52 MB-512 MB	50MFLOPS	COSMOS, DEEP BLUE, BLUE GENE, FLO SOLVER, PRAM, ANUPAM

where;
KB — Kilo Byte.
MB — Mega Byte.
MIPS — Mega Instruction Per Second.
MFLOPS — Mega Floating Operation Per Second.

(B) Categorization based on working system :

According to it computers are of five types :

(i) Digital Computers : These computers transform all the types of informations into a binary system and then operate. Such computers do all the calculations digitally by algebraic addition and can work in a more powerful manner. The specific characteristic of these computers are excellent and accurate numerical calculations.

(ii) Analogue Computers : In an analogue computer informations are resembled by any physical process through the electronic circuits in the form of electric symbols. Like digital computers which do simple numerical calculation, analogue computers similarly measure the computer and on the basis of resemblance these computers work.

(iii) Hybrid Computers : In hybrid computers both types of computers, digital and analogue are utilised and these computers are used today in the automatic operating devices (equipments). An equipment Robot through which a versatile (multi-purpose) working activities are completed is basically the composition of the hybrid computers.

(iv) Optical Computers : These computers are fabricated in the sequence of computers of fifth generation. In such computers one component is attached with another component through the optical fibres and calculations in such computers are done by an extensive optical system.

(v) Atomic Computer : The research and development activities in this regard is going on at Counnergy University in which any particular proton of the atoms can be adjusted and transformed into an Integrated Circuit (*IC*). Thus such computers acquire an extremely high memory storage capacity and power and have 10, 000 times more power than the present computers.

Functions of the Computer : There are four technical parameters on which any computer works successfully :

(i) Collection and composition (input) of data ;
(ii) Storage of data (iii) Processing of data
(iv) Retrieval or output of the processed informations and data

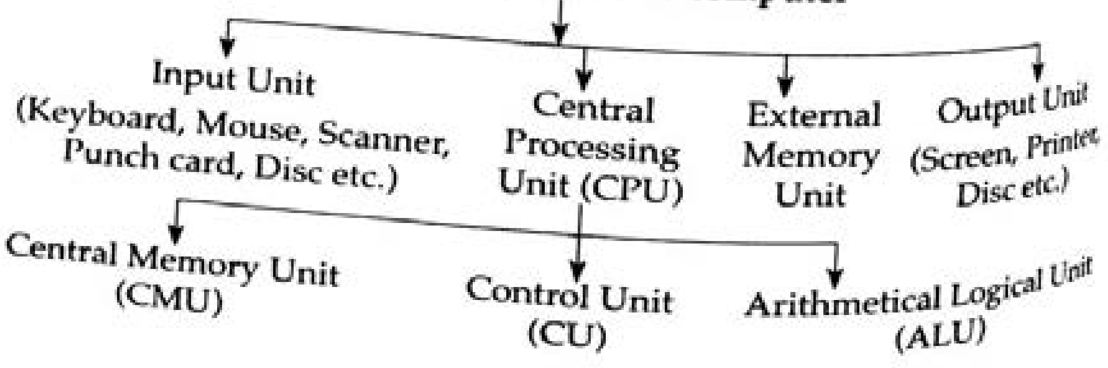
These informations or data are in the form of written, printed, listened, visible, graphics or in the form of mechanical indications.

Units of computer : There are four main components (units) of a computer :

(i) Input Unit (ii) Central Processing Unit (CPU)
(iii) External Memory Unit (iv) Output Unit

The data are entered through the Input Unit in the computer and data are arranged and processed through the Central Processing Unit with the help of External Memory Unit. Ultimately by the Output Unit these data or informations are issued (released). The CPU of the computer is called brain of the computer and sometimes CPU is also called Micro Processor of the computer.

Components of computer


Input Unit
(Keyboard, Mouse, Scanner, Punch card, Disc etc.)
Central Processing Unit (CPU)
External Memory Unit
Output Unit (Screen, Printer, Disc etc.)
Central Memory Unit (CMU)
Control Unit (CU)
Arithmetical Logical Unit (ALU)

Parts of Computer : Basically there are two parts in any computer and these are —

(A) Basic Parts :

Computer Unit or Main Computer : All the activities of the Personal Computers (PCs) are directly controlled by the Central Processing Unit (CPU) or regulated by the system of units. The rear (back) part of this unit is attached with a cable through which Key-Board, Monitor, Mouse, Printer etc. are composed. The Hard Disc and Floppy Disk are also attached inside this unit. These are in the form of Desktop type and Tosswer type :

Monitor : The monitor of the computer is like a television in which the picture appears in the form of dotted points on the screen and these are called pixels.

Hard Disc and Floppy Disc : To store informations or data, a disc is utilized in the computer and it is of two types—Hard Disc and Floppy Disc. The Hard Disc is the permanent disc in the computers while the Floppy Disc is the disc utilised when data or informations are to be transferred from one computer to another. The Hard Disc is larger in size than the Floppy Disc and operates more efficiently. In the front part of the computer there is a frame like structure in which Floppy Disc is suitably adjusted which is called Floppy Disc Drive.

(B) Optional Parts :

Mouse : The mouse of the computer is like the remote control of TV through which the computer is directly regulated (controlled) without utilising the key-board.

Printer : The printer is a device through which prints of any document is prepared or processed and all the printed informations of the computer are obtained. There are various types of printers like Dot Matrix Printer, Line Printer, Colour Printer, Inkjet Printer, Laser Printer etc. The Laser Printer is the most effective and a fine printing technique among all the computer printers but it is costlier than others. The laser printer is like a photocopier (Xerox) machine but the difference is only that the laser printer uses laser beam on behalf of photograph in making the sketch of the Graphics. Also through the laser printer very smooth and fine prints (printout) of the computer are obtained. Through laser printer, 13,000 lines can be printed out in every minute.

Scanner : The scanner of the computer is a device through which the image of the photograph is stored up or processed informations in the computer is made available. This acts like a photocopier machine but a photocopy in the computer is made on behalf of Xerox on the direct paper.

Computer Systems : Computer operates in two systems— Hardware and Software.

Hardware : In any computer all the components and mechanical equipments are called Hardware. Thus, Central Processing Unit (CPU). Internal Memory, External Memory, Input Unit, Output Unit etc are the components of Hardware.

There are two parts of the Hardware computers and other components of the system, like Modem, Printer, Disc, Tape recorders etc which are collectively called peripheral devices.

Software : The programs and instructions supplied to the computer are called software.

There are various types of software :

(i) Operating system : The operating system of the computer is a comprehensive program fabricated and designed for the internal working of the computer and for the consistent regulation of the components of the system.

(ii) Language processor : The user of the computer utilises a particular and specific program to run the computer which is called Language processor.

(iii) Application program : The programs selected by the computer user and which are conveniently and usefully selected from the commercial program of the computer and which are enlisted at the Menu are called Application program.

(iv) Subroutine program : The programs which are repeated again and again and which are small in size are called subroutine programs.

(v) Utility program : The programs composed with the operating system of the software computer and which appear again and again in various programs are called utility programs.

Languages of computer : There are various languages of the computer but broadly they can be classified into three :

(i) Machine code language : In this language every instruction has two parts— Operation code and Location code; both are represented by 0 and 1. In the earlier days of computer 0 and 1 were used by the programers to instruct the computer. But this language was time consuming due to which Assembly and others high level languages were started to use.

(ii) Assembly language : In this language a code which can be remembered easily was used and it is called memoric code like ADD for Addition, SUB for Subtraction, JMP for Jump etc, but this language was used for a definite type of computer. Thus, like machine code language, assembly languages were also called low level languages.

(iii) High level languages : The total contribution in the development of high level languages goes to IBM company and the first high level language FORTRAN was developed by this company. Later hundreds of such languages were developed. These high level languages are very similar to other ordinary languages which are spoken and written by human beings.

Some high level languages :

(i) FORTRAN : It is an abbreviation of the English letter Formula Translation. This is the first high level language developed by J. W. Bekas in 1957 who was a computer personnel in the IBM company. This language was developed for solving the mathematical formulae very quickly and conveniently.

(ii) COBOL : It is an abbreviation of Common Business Oriented Languages and this language was developed for the commercial purposes. For the processing of this language a group of sentences is selected which is called paragraph and all the paragraphs composed are called a section, while all the sections composed are called a division.

(iii) BASIC : It is an abbreviation of Beginners All Purpose Symbolic Instruction Code. Earlier all the high level languages are used completely or in other words complete program of the respective high level languages were inserted in the computer but in Basic a definite part of the prescribed instruction is only inserted in the computer.

(iv) ALGOL : It is an abbreviation of Algorithmic Language. This was basically fabricated and designed for the complex algebraic calculations.

(v) PASCAL : It is an amplified and modified form of ALGOL. In it every variable has been defined and it is different from ALGOL & BASIC. Its name was given by Blaise Pascal.

(vi) COMAL : It is an abbreviation of Common Algorithmic Language and this computer language is used for the students of secondary level.

(vii) LOGO : This language is used for children and kids for drawing Graphic line diagrams.

(viii) PROLOG : It is an abbreviation of Programing in Logic. This language was developed in 1973 in France and this language is used for Artificial Intelligence which is capable and equivalent to the logical program.

(ix) FORTH : This language was invented by Charles Mure which is frequently used in the all types of works in the computer.

In all the high level languages one resemblence is seen and observed that in almost all English capital letters A, B, C, D, E, ... etc and Indo-Arbian digits, 0, 1, 2, 3, ... are used.

Some others high level languages are PILOT, C, C^{++}, Lisp, Unix, Linus, Ada, Pl-1, SNOBOL etc.

Main Languages of various generations :

	Generation	**Languages**
I.	Gen. (1940-52)	FORTRON - I
II.	Gen. (1952-64)	FORTRON - II, ALGOL-60, COBOL, LISP.
III.	Gen. (1964-77)	PL/I, ALGOL-W, ALGOL-68, PASCAL, SIMULA 57, APL, SNOBOL, 4 BASIC, C.
IV.	Gen. (1971 to update)	CLVE, ALFARD, UCLID, REFORMED PASCAL, MODULA, EDA, ORACLE.
V.	Gen. (Future onward)	Artificial Intelligence Languages.

Computer virus : The computer virus is an electronic code which is used in abolishing (eradicating) the inclusive informations or programs of the computer. The computer virus can be injected into the computer through any telephone line and it is in fact a coinspiracy through which wrong informations transmit and all the collected and stored programs of the another computer attached with this network can be completely vanished or destroyed. Such computer viruses can also be spread by floppy exchange and these viruses can be found anywhere in any computer without any identification where they have been residing for many years or months. To check its unwanted spread electronic security zone and arrangement has been developed.

Some important computer viruses are Micheleanjalo, Dork Avangor, kilo, filip, Macmug, Scores, Casecade, Jeruslem, Date crime, Coloumbs crime, Internet virus, Pachcom, Pach EXE, COM-EXE, Marizuana, C-brain, bloody, Chenge Mungu and Desi etc.

Micheleanjalo virus was first seen in 1993. The first computer virus of India is C-brain which appeared for the first time in Chennai in 1988. An eminent company of Banglore has made a special arrangement to make the computer and its networking safe from the computer viruses.

Computer Networking : The use of computer networking is new but due to its many uses and benefits it has become customary in the computer world. Basically by the composition of computer and telecommunication technique, the networking process has originated. Computer networking is a mutual technique to compose various computers and the powers of these computers are collectively utilised.

There are two types of networkings which usually occur— Local Area Networking (LAN) and Wide Area Networking (WAN). By LAN all the computers of the same building are connected like the computers of the university premises, computers of the offices etc. But by WAN all the computers of a large area are connected like the computers of all the offices of a city or town etc. In India a very large computer network namely INDONET has been installed through which all the main towns and cities have to be interlinked.

Important facts related to computers :

- Charles Babbage is called the father of computers.
- John Wan Newman has made the most outstanding contribution in the development of computer.
- The modern computer was first invented in 1946.
- The great revolution in computer came in 1960.
- In the whole world the total number of computers are the largest in USA and then Japan, Germany, UK and France have their respective positions. India stands at the nineteenth place in this chronological order.
- Computer literacy means— what computer can do and what it can not ?
- Every year 2nd December is celebrated as the computer literacy day.
- In November 1984 the Government of India announced the new computer policy.
- The first computer fabricated and designed in India was Siddhartha and it has been fabricated (manufactured) by Electronic Corporation of India.

- The first computer of India was installed on 16th August, 1986 at the main post office of Banglore.
- The first computerised post office was installed at New Delhi.
- The first pollution free computerised petrol pump was installed in Mumbai.
- The first computer university of India was Rajiv Gandhi Computer University which is a private institution.
- The first computerised reservation system of India in the railways was started at New Delhi.
- Silicon Valley of India is located in Banglore.
- The first Indian newspaper available on the Internet is the Hindu, while the first Indian magazine available on the Internet is India Today.
- Among all the political parties in India BJP is the first party which has its own website on the Internet.
- There are three broad categorization of computer— digital, anologue and hybrid.
- The computer which does arithmetical (mathematical) calculations is called digital computer.
- The digital and the anologue computers jointly form the hybrid computer.
- The mini computer is the computer of middle size.
- The super computers are those which work ten times faster than an ordinary computer.
- In a super computer nearly 40,000 micro computers are assumed to be internally composed and in it calculations are done in megaflop.
- The first computer of the world was CRAYK–IS which was fabricated and designed by an American company Cray K Research in 1979.
- The Deep Blue is a computer which can work alone equivalent to 32 computers and through the Deep Blue in 1 second 20 crore multi option in the chess can counter the game plan of the opponent. Deep Blue was the computer through which chess world champion Garry Kasprov was defeated by Vishwanathan Anand.
- The first electronic digital computer of the world is ENIAC.
- The first largest computer network of the world is INTERNET.
- There are five generations of the computer which have till now been developed.
- In first Gen. computer vacuum tube diodes and triodes were used.
- Almost all modern computers use semiconductors in which memory are stored up.
- There are eight composer in the computer board.
- 1 Kilo Byte (KB) = 1024 Byte, 1 Mega Byte (MB) = 1024 Kilo Byte (KB).
- 1 Giga Byte (GB) = 1024 Mega Byte (MB).
- For the search of instructions and processed programs a specific language SNOBOL is utilised.
- Most frequently used operating system is WINDOWS.
- USENET is a technique to compose a system through which all the universities are accessed to each other.

- When a subscriber of Internet network is attached electronically with another network then it is called Gateway.
- The latest microprocessor of the Intel is Pentium IV.
- Trade Nelson was the first person who had written a book on Personal Computers (PCs).
- The author of the computer book *Soul* of *new machine* Tassi Kecdar got Pulitzer Prize.
- The first computer magazine was *Computer and Automation*.
- According to scientists, the Indian language Sanskrit is the most convenient and suitable for the computer.
- The instructions or programs enlisted in the computer are called Menu.
- The storage of the records is called File.
- The working system of the digital computer is totally based upon the numerical calculations.
- The first practical digital computer is UNIVAC.
- The FORTRON has been developed as the first computer language through which programs were prepared.
- COBOL which is a high level language is like the English language.
- In COBOL the most suitable documentation is possible.
- The assembly language of TRANSLATOR which is converted into the machine code is called Assembler.
- The translated program which is simply the transformation of a high level languages into a lower level language is called compiler.
- The language BASIC is the mastermind of all the languages like FORTRON, ALGOL, PASCAL etc. which can be directly learned from BASIC.
- The microprocessor is the computer of the fourth generation.
- PROLOG is a language of the fifth generation Gen. Computer.
- The Integrated Circuit (*IC*) chip on which there is a layer (coating) of silicon was developed by J. S. Kilvi.
- The impurity in the computer is called Bug.
- In 1988 C-DAC (Centre for Development & Advanced Computing). Pune was established. The scientists of C-DAC fabricated a computer called Pram-10, 000 which can calculate a billionth of billion in a fraction of a second. The outstanding contribution in the development of Pram-10000 goes to Dr. Vijay P. Bhaskar.
- The first super computer FLOSOLVER was developed first in India and fabricated by the National Aeronautics Laboratories (NAL) Banglore.
- The nuclear tests on the computer are called subcritical test.
- Laser printer is the most effective and powerful printer among all.
- IBM (International Business Machine) is an American computer company.
- The computer virus is a manmade digital parasite which is also called File infectioner.
- Y-2K problem or year 2000 crisis was a computer problem related to the date and year in which all the rightmost digits became zero. The Y-2K crisis is also called a millenuim bug.

- Modem is a device through which all the computers are attached electronically and it operates on the telephone line.
- The network of internet where a special type of information, program are available is called a site.
- The informations or messages through any network near or far can easily be facilitated on their own network by the modem is called Download.
- But if the informations or messages are sent from their own network to any other network by the modem, then it is called Upload.
- In any computer or in its Hard Disc or in running programs if any discrepancy appears then it is called a Crash in computer.
- The development of the computer began in 1955 in India.
- IISc (Indian Institute of Science), Banglore has developed a multi languages computer whose touchscreen has been named simputer and through this computer, village to village computer compaign has brought a comprehensive revolution.
- India's first computerium has been established at Banglore.
- India's first fully computerised village is Bellanad in Thiruvanantpuram district of Kerla.
- Personal Computer (PC), Home computer, electronic diary (Briefcase computer) etc are examples of micro computers.
- Some customery operating system of micro computers are—CP/M, MacOS (Apple), DOS, Pro DOS, MS/DOS/p.c. DOS, XENIX, UNIX, WINDOWS, LINUX etc.
- The speed of CPU is called clock speed.
- The instructions given by the computer user or computer operator is called command.
- The computer networks attached electronically by various networks of the computer of various places of the world through telephone lines or satellites is called INTERNET.
- In the Internet full informations are stored up in the computers and in the technical language it is called web server.
- The inclusive informations of every computer is called Home page.

Computer Terminology :

Application program : A program which is performed for a definite work is called application program. Like work processing or database management or software of Accounting work etc. Here for the word processing MS word, for database visual FOXPRO, for designing Adobe photoshop and for accounting Tally are application programs and these are called softwares.

Bit : The bit is a unit of measurement of the electronic data. One bit is either 0 or 1 but both never. One bit depends on the number which clearly indicates how data can be stored up within it. On composing 8 bits, 1 byte is formed.

Boot : The starting work done by the operating system in any computer to bring the computer in full working condition is called boot.

Bug : Bug is the error in the computer program or system and its eradication is called Debug.

If any computer starts to supply wrong or faulty programs then it is said that there is a bug in the program.

Byte : Total eight bits compose a byte.

Thus, 8 bits = 1 byte.

Cache : This is also a type of memory which is utilised for temporary storage. In it those data are kept which are frequently used. Due to it the processing rate of computer increases. Cache is of various levels and it acts like a bridge between the processor and Ram and through it the speeds of processor and Ram can be balanced.

CD-ROM : A CD like a music CD in which data can be stored substantially is called CD-Rom. In a CD with comparison to floppy disc a lot more data can be stored but one problem in it is that one-time recorded data cannot be deleted or modified. Also on CD to write and to read there is a need of CD-drive and writer.

Chip : It is a thin slice on which by a special mechanism a circuit is designed which is normally made of Silicon. At present on behalf of silicon, Galium Arsenide (GaA) Chip and Protin chip (bio chip) are being prepared and research and development activities are going on for another.

Computer Program : For the working of the computer the group of instructions written in low or high level computer languages are called computer program.

Compiler : The program which converts high level languages into the languages of machine is called compiler.

CPU : This is Central Processing Unit and it is called heart-mind of the computer. It is basically a chip attached to the mother board of the computer and the complete main processing are confined here.

P-III, P-IV, AMD Athlon etc. are the examples of CPU.

Curser Key : The button on Key-Board on which there is a symbol of an arrow is called cursor-key. It is used to move cursor on the screen.

File : The collection of data which are saved for a particular name is called File, like salary sheet of any person, any song MP3 etc. are the examples of file.

Database : The collection of data in which from phone book to inventory management of any company are enlisted and enclosed are called Database.

Error Message : The messages displayed by any software in which some error has been detected is called error message.

Floppy Disc : It is like a tape recorder cassette in which data are stored up but it is very small and convenient to carry out. Today the floppy disc has its size of up to 3.5 inch.

Giga Byte : 1024 Mega Byte (MB) is called 1 Giga Byte (GB). Thus, 1 Mega Byte = 1024 × 1024 Bytes.

Today the fabricated Hard Discs have the capacity in the order of Giga Bytes.

Graphic User Interface- (GUI) : It is a visual interface in which files, commands, softwares etc. are displayed in the form of icon (graphical trace). These graphical traces are selected and utilised by any mouse like pointing device. Graphical user interface windows is available in atmosphere which operates by clicking through user icons.

Hacker : If anybody damages or produces error in the computer knowingly then this is called Hacking and the person is called Hacker.

Hard Disc: It is a data storage device which is kept inside the cabinet and through it a large amount of data are collected and stored. Also Hard Discs are of different shapes and sizes to enable the user to select it appropriately.

Hardware : The mechanical part of the computer which can be touched physically is called Hardware. Monitor or Key-Board is the example of a Hardware.

Icon : The small graphical traces displayed on the screen which may represent any program, commander file is called Icon.

Mega Hertz (MHz) : 1 Mega Hertz represents 10,00000 cycle per second. If a micro processor has the working capacity of 200 MHz it means it will run with 200 00 00 00 cycle / second. This also tells us how powerful microprocessor is ? The speed of the microprocessor is measured in clock speed.

Memory System : The place where computer data and program are temporarily kept is called Memory system. Usually memory is implied from RAM.

Modem : The device which converts the digital signals into the anologue signals and vice-versa is called Modem. In fact this device (Modem) is utilised in connecting computer through the telephone lines. Modem is also utilised in the connection of internet.

Mother Board : Inside the cabinet of the computer there is a board on which CPU, Memory etc. circuits are connected. It is called Mother Board and on it some other cards may also be attached.

Network : The net of various computers in which computers are interconnected by cable or any medium is called Network. The main advantages of Network is user file can be utilised or shared by another user.

Operating System : The software which is capable of doing work by some fundamental means is called operating system. In the fundamental system operations all the activities like to read, to write about data, resources management etc. are assumed under the operating system.

Peripheral : The Hardware devices which are attached to any computer additionally are called peripheral. Basically these are not parts of the original computer.

Pixel : The smallest part of any image is called pixel. A pixel of a monitor is represented by a very small dot (.). Such various dots compose an image. At a particular place if there are a large number of pixels then the quality of the image will be fine.

Pointer : The component in the form of an indicator which is attached to the mouse and controlled through it, appears on the computer screen is called pointer. The pointer moves in the direction in which the mouse pad moves.

Port : This is basically a connector which connects external devices through the mother board. In a particular computer there may be different types of ports, like parallel port or serial port or USB port.

RAM : It is Random Access Memory (a place) where processed data are kept temporarily and it is a unstable memory. As power is cut through the computer its contact is automatically ended and the memory is lost. Memory is also measured in Megabytes.

ROM : It is Read Only Memory and it is stable or non-volatile memory which doesn't end if power stops.

Reboot : The Booting means to start computer from the rest while Rebooting means to start computer once again which is not in rest. Usually the process of Reboot occurs when the computer automatically stops due to any reason or any software is installed along the parallel etc.

Sound Card : It is a card which is attached with acousting working in the Personal Computer (PC).

Scanner : It is a device through which graphic image is transformed to the digital image and the scanners are of usually two types : one is desktop and another is hand operating.

System unit : The box like cabinet part of desktop PC is called system unit and inside it mother board and another chips are attached.

Touch Screen : The computer in which by touching monitor, instructions are given on behalf of Key-Board.

Virus : A software which is fabricated to damage data by any means is called computer virus. Normally virus tends to damage the files by entering through the operating system.

Abbreviations related to computers

ALU	Arithmetic Logic Unit.
ALGOL	Algorithmic Language.
✓*ASCII*	American Standard Code for Information Interchange.
✓*BASIC*	Beginner's All Purpose Symbolic Instruction Code.
BCD	Binary Coded Decimal Code.
✓*BIOS*	Basic Input Output System.
CPU	Central Processing Unit.
CAD	Computer Aided Design.
CAM	Computer Aided Manufacturing.
CAT Scan	Computerised Axial Tomography Scan
COBOL	Common Business Oriented Language.

CD	Compact Disk
C-DOT	Centre for Development of Telematics.
COMAL	Common Algorithmic Languages.
DOS	Disk Operating System.
DTS	Desk Top System.
DTP	Desk Top Publishing.
E-Commerce	Electronic Commerce.
E-Mail	Electronic Mail
ENIAC	Electronic Numerical Integrator And Calculator.
FAX	Facsimile Automated Xerox.
FLOPS	Floating Operations Per Second.
FORTRAN	Formula Translation.
HLL	High Level Languages.
HTML	Hyper Text Markup Language.
IBM	International Business Machine.
IC	Integrated Circuit.
ISH	Information Super Highway.
LAN	Local Area Network.
LDU	Liquid Display Unit.
LISP	List Processing.
LLL	Low Level Language.
MICR	Magnetic Ink Character Recoginizer.
MIPS	Millions of Instructions Per Second.
MOPS	Millions of Operations Per Second.
MODEM	Modulator-Demodulator.
MPU	Micro Processor Unit.
NICNET	National Information Centre Network.
OCR	Optical Character Reader.
OMR	Optical Marker Reader.
PC-DOS	Personal Computer Disk Operating System.
PROM	Programmable Read Only Memory.
RAM	Random Access Memory.
ROM	Read Only Memory.
SNOBOL	String Oriented Symbolic Language.
UPS	Uninterruptable Power Supply.
VDU	Visual Display Unit.
VLSI	Very Large Scale Integrated.
WAN	Wide Area Network.
w.w.w.	World Wide Web

Objective Question

1. Who is called the father of computer ?
   (a) Herman Holerith (b) Charles Babbage
   (c) Wales Pascle (d) Wan Newmaan
2. The most outstanding contribution in the development of computer is given to —
   (a) Herman Holerith (b) Charles Babbage
   (c) Wales Pascle (d) Wan Newmaan
3. The most outstanding contribution in the development of the blue pr of the first digital computer goes to :
   (a) Herman Holerith (b) Charles Babbage
   (c) Wales Pascle (d) William Buros
4. The first modern computer was invented in :
   (a) 1946 (b) 1950 (c) 1960 (d) 1965
5. What is the full form of e-mail ?
   (a) Electronic mail (b) Electric mail
   (c) Electromagnetic mail (d) None of these

   [MPPCS (Pre) 2011]
6. The written material (recorded in the chip), which is required for the operation of computer like employed program, direction and other computer related activities is called :
   (a) Software (b) Hardware
   (c) Network (d) Firmware
7. The controlling unit of the computer is called :
   (a) Printer (b) Keyboard (c) CPU (d) Hard disc
8. The brain of the computer is called :
   (a) Memory (b) Keyboard (c) CPU (d) Hard disc
9. What can be sent through video mail ?
   (a) Graphics (b) Video clips
   (c) Video messages (d) All of these *[MPPCS (Pre) 2011]*
10. The computer hardware which can store a very large amount of data is called :
    (a) Disc (b) Chip
    (c) Magnetic tape (d) None of these
11. Who developed the integrated circuit chip ?
    (a) C. V. Raman (b) Robert Nayak
    (c) J. S. Kilvi (d) Charles Babbage
12. The layer on the integrated circuit chip (IC) is made of :
    (a) Silicon (b) Nickel (c) Iron (d) Copper
13. The layer of the magnetic disc is made of :
    (a) Iron oxide (b) Phosphorus penta oxide
    (c) Magnesium oxide (d) Sodium peroxide
14. The length of the word through which computer does the measurement :
    (a) Byte (b) Bit (c) Meter (d) Milimeter

15. Which one of the following is measured in Megabyte :
(a) Intensity of the earthquake
(b) Population density
(c) The capacity of power expenditure
(d) The memory power of the computer

16. The process of carrying out commands is called :
(a) Fetching (b) Storing (c) Decoding (d) Executing
[MPPCS (Pre) 2011]

17. One kilobyte (1 KB) is equivalent to :
(a) 1000 byte (b) 1024 byte (c) 10000 byte (d) 100000 byte

18. Which of the following is not a search engine ?
(a) Google (b) Altavista (c) Science direct (d) Orkeet
[MPPCS (Pre) 2011]

19. The memory word of the computer is associated with :
(a) Logic (b) Control (c) Input (d) Storage

20. Computer hardware which can store very large amount of datas is called :
(a) magnetic tape (b) disc
(c) both of these (d) None of these

21. Size of virtual memory depends on :
(a) Address lines (b) Data base (c) Disc space (d) All of these
[MPPCS (Pre) 2011]

22. The digital computer operates on the principle of :
(a) calculation (b) measurement
(c) electricfication (d) logical

23. The fastest printer in the computer is :
(a) Laser printer (b) Jet printer
(c) Thermal printer (d) Dazy wheel printer

24. Super computers are different from other computers in respect to :
(a) extremely high cost (b) airconditioning problem
(c) simplification capacity and large memory storage
(d) multipurpose use

25. The system used in the modern digital computer is called :
(a) binary digital system (b) decimal digital system
(c) analogue calculation system (d) none of these

26. Which one of the following is the scientific language of the computer?
(a) BASIC (b) COBOL (c) FORTRAN (d) PASCAL

27. The computer language FORTRAN is frequently used in the area of :
(a) business (b) graphics (c) science (d) commerce

28. The computer language COBOL is useful for :
(a) the business work (b) the graphics work
(c) the scientific work (d) None of these

29. The computer language which is specially used in the commercial activities is—
(a) FORTRAN (b) BASIC (c) COBOL (d) PASCAL

30. The first computer language developed for the program is :
    (a) FORTRAN (b) PASCAL (c) COBOL (d) BASIC

31. The high level computer language like English language is :
    (a) FORTRAN (b) PASCAL (c) COBOL (d) C^{++}

32. Through which one of the following computer languages most useful documentation is possible ?
    (a) FORTRAN (b) COBOL (c) PASCAL (d) C^{++}

33. The language which is necessary to learn the language like FORTRAN, ALGOL, PASCAL etc. is
    (a) C^{++} (b) BASIC (c) COBOL (d) None of these

34. The program language used for the computer scientific calculations is :
    (a) BASIC (b) FORTRAN (c) COBOL (d) PASCAL

35. Which one of the following work can be done through the use of BASIC language?
    (a) commercial activities
    (b) scientific calculation
    (c) teaching the children
    (d) understanding the simple language at initial stage

36. The language which the computer understands and through which the processing in the computer occurs is called :
    (a) American language (b) Machine language
    (c) Secretly decoded language (d) None of these

37. Who was the inventor of computer language JAVA ?
    (a) IBM (b) Microsoft
    (c) Sun Microsoft (d) Infosystem

38. Most of the computers can understand :
    (a) high level instructions
    (b) BASIC which resembles like English
    (c) any language (d) none of these

39. The computer grid is :
    (a) a hardware component of the computer
    (b) a software inner structure in which a number of calculative systems are attached
    (c) a primitive prototype of the super computer
    (d) a hardware component of long hydron assembly for the nuclear research

40. The software windows software has been fabricated (manufactured by :
    (a) IBM (b) Apple corporation
    (c) Wipro (d) None of these

41. The Oracle is :
    (a) an operating system (b) a word processor software
    (c) a database software (d) None of these

42. Which one of the following software is used in the word processing :
(a) Pagemaker (b) Word star (c) M.S. word (d) All of these

43. The password provides a protection to the computer which :
(a) safeguards the oldness came in the hardware
(b) safeguard the discrepancies came in the software
(c) safeguards the unauthorized entry of the system
(d) none of these

44. The system through which the data by the means of telephone and with the help of binary signals are transported is called :
(a) Modem (b) Monitor (c) Mouse (d) OCR

45. The inability came in four digit system of data storage of the computer is called :
(a) Y-2K problem (b) data bug
(c) 4D problem (d) computer bug

46. What do you understand by hacking ?
(a) Searching (b) Security
(c) Both (a) and (b) (d) None of these

[MPPCS (Pre) 2011]

47. The computer literacy day is celebrated on—
(a) 1 December (b) 2 December (c) 19 December (d) 22 December

48. The fastest super computer developed by NASA is :
(a) Kalpna Chawla (b) Columbia
(c) Blue gene (d) Param

49. Microsoft word is an example of :
(a) an operation system (b) an input device
(c) a processing device (d) application software

[MPPCS (Pre) 2011]

50. The world's first electronic digital computer is :
(a) ENIAC (b) Sidhartha
(c) Param (d) Deep

51. The first computer which had been fabricated and developed in India is—
(a) Sidhartha (b) Param (c) Megha (d) Cyber

52. Microsoft is an :
(a) institution where microchip is prepared
(b) institution where the softwares are developed
(c) institution of micro engineering
(d) institution where the hardwares are developed

53. The word MB is used for :
(a) Magnetic Bits (b) Mega Bytes
(c) Mega Bits (d) None of these

[Uttrakhand PCS (Pre) 2008]

54. Which one of the following is a computer virus—
(a) Fungi (b) Bacteria
(c) IC 7344 (d) Software program

[UPPCS (Pre) 2010]

55. Which one of the following is called *Information Gateway* :
(a) E-mail (b) Pager
(c) Cellulor phone (d) Internet

56. Who is called the father of E-mail ?
(a) Bill Gates (b) Timothy Bill
(c) Linkan Golitsberg (d) Rey Tomlinson

57. The first computer in India was installed at :
(a) IIT Delhi in 1973 (b) IISc Banglore in 1971
(c) IISCO in 1965 (d) ISO Kolkata in 1955

58. Which one of the following is permitted under the bluetooth technology ?
(a) Wireless communication between the equipments
(b) Only Signal transmission on the mobile phones
(c) Mobile phone communication through landline
(d) Satellite television communication

[CDS 2010]

59. Through which one of the following the speed of the processor of the computer is measured ?
(a) BPS (b) MIPS (c) BOD (d) Hz

[SSC Graduate Level 2010]

60. The full form of www is :
(a) web working window (b) window word wide
(c) world wide web (d) world working web

61. What is the meaning of RAM in the context of a computer ?
(a) Recent And Ancient Memory (b) Random Access Memory
(c) Read And Memory (d) Recall All Memory

62. CPU implies :
(a) Control and Primary Unit (b) Central Processing Unit
(c) Computer and Process Unit (d) None of these

63. CAD implies :
(a) Computer Algorithm for Design
(b) Computer Added Design
(c) Computer Application in Design
(d) None of these

64. The full form of IBM is :
(a) Indian Business Machine
(b) International Business Machine
(c) Italian Business Machine (d) Integral Business Machine

65. The CD-ROM stands for—
(a) Core Disc – Read Only Memory
(b) Compact Disc – Read Only Memory
(c) Circular Disc – Read Only Memory
(d) None of these

66. Which one of the following products is sold in the market by the name of pentium brand :
(a) Mobile chip (b) Computer chip
(c) Computer (d) Microprocessor

[UPPCS (Pre.) 2004]

67. Who was the inventor and founder of www ?
(a) Bill Gates (b) Lee N. Fiyong
(c) N. Russel (d) Timbernrus Lee
[UPPCS (Pre.) 2004]

68. Yahoo, Google and MSN are :
(a) Internet sites (b) computer brand
(c) watches made of Switzerland (d) the ring of the planet Saturn

69. In the computer dictionary the word CD stands for :
(a) Compact Disc (b) Compressed Disc
(c) Computerized Data (d) Compressed Data

70. Which one of the following is not a computer language ?
(a) BASIC (b) C
(c) FAST (d) FORTRAN
[41st BPSC (Pre.) 1996]

71. Which one of the following terms is not associated with information technology ?
(a) Cyber space (b) Upload
(c) Light storage (d) Modem
[UPPCS (Pre.) 2001]

72. The fastest computer of the world is :
(a) T–3A (b) Yenha–3 (c) Param–10,000 (d) J–8
[UP Lower Sub. 1998]

73. What is Anupam ?
(a) a research Institute (b) a super computer
(c) a newly designed missile (d) a computer software
[CPO, AC 1994]

74. A supercomputer *Param* has been developed and designed in India by :
(a) C – DAC, Pune (b) IIT, Kanpur
(c) BARC, Mumbai (d) IIT, Delhi [RAS/RTS 1992]

75. The smallest unit of computer data is—
(a) byte (b) bit (c) record (d) file
[IAS (Pre) 1987]

76. The Michele Anjelo Virus is :
(a) a cancerous virus (b) a cancer protective virus
(c) viruses spread in rats (d) a computer virus
[MBA Entrance R.U. 1994]

77. Which one of the following is applicable to all the computers ?
(a) BASIC (b) COBOL
(c) Machine language (d) FORTRAN
[MBA Entrance AMU 1995]

78. The APPLE is :
(a) a fruit
(b) a computer of fourth generation
(c) a computer network
(d) a computer language [MPPCS (Pre) 1993]

79. The system which transforms the data into impulses and these impulses are sent from a terminal to a computer and from a computer to a terminal in a compressed way is called :

(a) Magnetic disc
(b) Micro computer
(c) CD–Rom
(d) Modem

80. The fastest computer of the world which would follow the working mechanism of the human's brain is :

(a) Supercomputer
(b) Quantum computer
(c) Param – 10,000
(d) IBM chips

81. Which one of the following has been developed as a Supercomputer Project by the Bhabha Atomic Research Centre (BARC) ?

(a) Param Padam
(b) Flosalver Mark
(c) Chips
(d) Anupam *[UPPCS (Pre) 2004]*

82. The memory of a computer is usually expressed in kilobyte or megabyte; one byte is basically composed of :

(a) 8 binary digits
(b) 2 binary digits
(c) 8 decimal digits
(d) 2 decimal digits

[IAS (Pre) 2000]

83. A popular windowing Environment, windows – 3 issued in :

(a) 1985 (b) 2000 (c) 1995 (d) 1990

84. The computer :

I. is a capable system in which data are stored up
II. is capable in performing excellent analysis of the data
III. is able to have the secrecy of something
IV. is affected sometimes by the viruses

Select the correct answer from the following :

(a) I & II (b) II & III (c) I, II & IV (d) All of these

[Uttarakhand PCS (Pre) 2005]

85. In an arrangement of computerization there is a need of :

I. a great willpower to perform
II. an associated financial resource
III. a trained manpower
IV. a ultramodern installed configuration

Select the correct answer from the following :

(a) I & II (b) II & III (c) I, II & IV (d) All of these

[Uttarakhand PCS (Pre) 2005]

86. The working function of an assembler is :

(a) to transform BASIC language into a mechanical language
(b) to transform a high level language into a mechanical language
(c) to transform an assembly language into a mechanical language
(d) to transform an assembly language into a high level language

[Uttarakhand PCS (Pre) 2005]

87. The supercomputer Deep Blue and Blue Gene are developed and fabricated by :

(a) IBM Co. USA
(b) Combridge University, UK
(c) BARC, Mumbai
(d) None of these

88. The main component of the fifth generation computer is :
    (a) Integrated circuit (IC) (b) Largely Integrated Circuit (LIC)
    (c) Optical fibre (d) None of these

89. The abbreviation of ENIAC is :
    (a) Electronic Numerical Integrator And Calculator
    (b) Electronic Numerical Integer And Calculator
    (c) Electronic Not Integrator And Calculator
    (d) None of these

90. The supercomputer Flo Solver of India was developed and designed by :
    (a) NAL, Banglore (b) C–DAC, Pune
    (c) BARC, Mumbai (d) None of these

91. The Central Processing Unit (CPU) which is called the brain of the computer, is sometimes also called :
    (a) Microprocessor (b) Processor
    (c) Mini processor (d) Mini computer

92. Which one of the following is not the component of a computer ?
    (a) Input unit (b) CPU
    (c) External Memory Unit (d) Internal Memory Unit

93. Which one of the following is a part of Input Unit ?
    (a) Keyboard (b) Mouse
    (c) Punch Card (d) Printer

94. The language 'C' used in the computer is a :
    (a) Low level language (b) High level language
    (c) Machine code (d) Conjugation level language

[SSC Graduate Level 2010]

95. The inventor and propounder of www was :
    (a) Bill Gates (b) Lee. N. Feyong
    (c) N Russel (d) Tem Burners Lee

[UPPCS (Pre) 2004, IAS (Pre) 2007]

96. Which one of the following languages of the computer has been developed from a pure business point of view ?
    (a) COBOL (b) BASIC
    (c) FORTRAN (d) None of these

97. The first Computer University of India is :
    (a) Rajiv Gandhi Computer University
    (b) Indira Gandhi Computer University
    (c) Jawahar Lal Nehru Computer University
    (d) None of these

98. The first pollution free computerised petrol pump has been installed at :
    (a) New Delhi (b) Chandigarh
    (c) Mumbai (d) Noida

99. The first main post office of India where a computerised system begun to work—
    (a) New Delhi (b) Banglore
    (c) Chandigarh (d) Noida

100. The political party which has opted firstly its own website in India is :
    (a) BJP (b) INC
    (c) DMK (d) AIADMK

Answers

1. (b)	2. (d)	3. (b)	4. (a)	5. (a)	6. (a)	7. (c)	8. (c)
9. (d)	10. (b)	11. (c)	12. (a)	13. (a)	14. (b)	15. (d)	16. (d)
17. (b)	18. (c)	19. (d)	20. (c)	21. (a)	22. (a)	23. (a)	24. (c)
25. (a)	26. (c)	27. (c)	28. (a)	29. (c)	30. (a)	31. (c)	32. (b)
33. (b)	34. (b)	35. (d)	36. (b)	37. (c)	38. (a)	39. (b)	40. (d)
41. (c)	42. (d)	43. (c)	44. (a)	45. (a)	46. (c)	47. (b)	48. (b)
49. (d)	50. (a)	51. (a)	52. (b)	53. (b)	54. (d)	55. (d)	56. (d)
57. (d)	58. (a)	59. (b)	60. (c)	61. (b)	62. (b)	63. (b)	64. (b)
65. (b)	66. (d)	67. (d)	68. (a)	69. (a)	70. (c)	71. (c)	72. (a)
73. (b)	74. (a)	75. (b)	76. (d)	77. (c)	78. (b)	79. (b)	80. (b)
81. (d)	82. (a)	83. (b)	84. (d)	85. (d)	86. (c)	87. (a)	88. (c)
89. (a)	90. (a)	91. (a)	92. (d)	93. (d)	94. (b)	95. (d)	96. (a)
97. (a)	98. (c)	99. (b)	100. (a)				

★★★

04. Chemistry

Chemistry : The word chemistry originates from an Egyptian word *Chemeo* (means black colour). In early days the study of chemistry was called *Chemeteching*. The chemistry is a branch of natural science in which the properties, composition and structure of the matter alongwith some other changes because of action and reaction are studied. In other words, a branch of natural science in which we study about the law of mutual composition of the matter, the effect of thermal energy on the matter, the synthesis of the compounds, the separation of the simplified and pure substances from the complex substances is called chemistry. The chemist Lavoisier is called the father (originator) of *Modern Chemistry.*

Various branches of Chemistry :

1. **Physical Chemistry :** The branch of chemistry under which the laws of chemical reactions alongwith various theories and principles are studied.
2. **Inorganic Chemistry :** The branch of chemistry under which the all inorganic elements and their compounds are studied.
3. **Organic Chemistry :** The branch of chemistry under which the compounds of carbon are studied.
4. **Bio-Chemistry :** The branch of chemistry under which the chemical substances obtained from animals, plants and some others are studied.
5. **Industrial Chemistry :** The branch of chemistry under which the large scale composition of the substances, the related laws, and the chemical reactions concerned to these processes are studied.
6. **Agricultural Chemistry :** The branch of chemistry under which agro based chemistry like insecticide, virology, composition of the soils etc. are studied.
7. **Medicine Chemistry :** The branch of chemistry under which medicines, their composition, manufacturing processes etc are studied.
8. **Analytical Chemistry :** The branch of chemistry under which various substances are identified, and the volume and mass of these substances and measured.

I. Physical Chemistry

1. States of matter

Matter : The matter is that substance which occupies space, has a definite mass, can exert pressure, can produce physical resistance, has the virtue of inertia, states may be transformed through the energy, which can be decomposed or divided and whose existence be realised by our sence organs.

Types of matter

Broadly the matter has been divided into two categories :

1. On the basis of Physical composition.
2. On the basis of Chemical composition.

1. Physical composition of the matter : On the basis of physical composition, the matter is divided into three groups— solid, liquid and gas. The physical composition of the matter totally depends on intermolecular forces existing among their molecules.

Solid : The solid is that state of a substance (matter) whose shape and volume (hence size) both are definite. For examples table, book, stone pieces etc. When the intermolecular forces of attractions among the molecules of the substance is stronger than forces of separation then the substance is said to be in the solid state. Due to stronger intermolecular forces the molecules of the solid substance are compressed in densed form whose locations are fixed. At this position the molecules of the solid vibrate (oscillate) about this position in intermolecular domain. That's why all the solids have a definite shape and size.

Liquid : The liquid is that state of a substance (matter) whose volume (hence size) is definite but shape is not definite like water, milk, oil, wine etc. The substance which can flow is called fluid that's why all the liquids are fluids. It is also observed that whatever be the shape of the liquid its upper surface is always plane. When the intermolecular forces of attraction among the molecules are only slightly greater than the corresponding forces of separation then the substance (matter) is in the liquid state. Thus, the molecules of the liquid are less densely compressed and these are free to move randomly within the substance. Although the intermolecular separation is not too large that's why it can change its shape but not its volume.

Gas : The gas is that state of the substance whose shape and size (volume) both are indefinite and its examples are air, H_2, N_2, O_2 etc. The gases also have no definite shape and size but only occupy the shape and size of the container in which these are kept. Also all the gases are flowing substance that's why these are also called fluids. When the intermolecular forces of attraction are weaker than corresponding forces of separation the substance is found to be in the gaseous state. The molecules in the gas are remotely distributed and so intermolecular separation are too large and molecules are free to move randomly that's why it has no definite shape and size.

2. Chemical composition of the matter : On the basis of the chemical composition, the matter is divided into three groups— element, compound and mixture.

Element : The element is that fundamental substance which can not be decomposed (divided) into two or more different components which have different properties (characteristics) by any physical or chemical process.

In other words, the element is that fundamental matter which is made from identical atoms and it can not be decomposed through any complex synthesis of two or more different components by any physical or chemical process.

On the basis of electronic configuration an element is that substance whose atoms have the same nuclear charges. The examples of element are H_2, O_2, N_2, Na, Fe, Cu, Ag etc. The element is of two types— Metals and Non-metals. The metals are usually good conductors of electricity and heat and mostly found in the solid states which are malleable and ductile. The examples of metals are Fe, Cu, Al, Ag, Pt, Au etc. The non-metals are usually bad conductors of electricity and heat, and these are brittle. On the basis of physical composition since matter is found to be in solid, liquid and gas that's why elements are also to be found in these three states.

Most of the elements are solids like Fe, Cu, C, S, Ag, etc., while some are liquids like Hg, Br etc. and some others are gases like H_2, O_2, N_2, Cl_2 etc. At present there are 112 elements which have been discovered. Out of 112 elements, 92 elements are naturally occurring and the rest elements are artificially made by the complex synthesis in various laboratories of the world.

Compound : The compound is a pure substance which is formed by the chemical combination of two or more elements in a definite ratio. Also the physical and chemical properties of the compound are different than that of its constituent or component elements.

The examples of the compound are CO_2, H_2O, $KMnO_4$, H_2SO_4 etc. For example, H_2O (water) is a compound which is formed by the chemical combination of 2 atoms of hydrogen and 1 atom of oxygen but by weight it has the ratio of 1 : 8. The physical and chemical properties of the water are different from hydrogen and oxygen.

Mixture : The mixture is an impure substance which is formed by the combination of two or more pure elements by the means of a physical process and it doesn't has any definite ratio. Also the components or constituents of the mixture can be separated by any simple or physical process or by any mechanical process.

The examples of the mixture are— air, brass (copper + zinc) etc. Air is a mixture of various gases like N_2, O_2, CO_2, etc. and water vapour.

Types of mixture : On the basis of the nature of constituent (component) element and on the properties and the composition of the mixture it is categorised into two groups—

(i) Homogeneous mixture : The mixture in which the every part has the same composition and properties as that of its component elements is called homogeneous mixture.

The examples of homogeneous mixture are the electrolyte of sugar in water, the electrolyte of sulphur in carbon disulphide, the electrolyte of NH_3 in air etc.

(ii) Heterogeneous mixture : The mixture in which the every part has not the same composition and the properties as that of its components elements is called heterogeneous mixture.

The examples of heterogeneous mixture are the mixture of iron and sulpher, the mixture of silica (sand) and salt, the mixture of dust particles in air etc.

It is also observed that the component elements of the heterogeneous mixture can be easily separated than the component elements of the homogeneous mixture.

The component (constituent) particles of the substance (matter):

Molecule : The smallest particle of the substance (element or compound) which can exist in free state but doesn't take part in chemical reactions and the properties of the substance (element or compound) are exactly present in it, called molecule.

The molecules of the substance are identical (same mass, shape, size) in every aspect but two different substances have different molecules in mass, shape and size.

For example— water (H_2O) has all the identical molecules and similarly common salt (NaCl) has also the identical molecules but a molecule of H_2O is not identical as a the molecule of NaCl. The forces operative within these molecules are called intermolecular forces of attraction and due to these forces substances exist as solid or liquid, while in gas the existence of these forces become insignificant.

Types of molecule : There are two types of molecules—molecule of the element and the molecule of the compound. When the atoms of the same element are composed together then the smallest independent particles form and these particles are called molecules of the element. For example, the molecule of the nitrogen (N_2) has been composed from two atoms of the nitrogen.

Also the atoms of the element are identical in every respect for a particular element.

But when the atoms of more than one elements compose the smallest independent particles then these particles are called molecules of the compound. For example— each molecule of ammonia (NH_3) has been composed from one atom of nitrogen and three atoms of hydrogen.

Atom : The smallest particle possible in the substance or element which doesn't exist in free state but takes part in chemical reactions and all characteristics of the substance or element are present in it is called the atom of the substance or element.

Earlier theories of atomic models assumed that the atom is the ultimate smallest particle of the substance (matter) or element and it can not be divided (decomposed) further. Dalton also supported this view but later atomic theories clearly speculated and asserted that the atom is divisible and it is basically composed or constituted from electron, proton and neutron. The atoms of an element are identical in every respect but these are different for the atoms of other element. Thus the atoms of carbon are not identically same as the atoms of Nitrogen.

Separation of mixture : The components (constituents) of the mixture are separated by various processes which are given as below :

1. Process of crystallisation : By the process of crystallisation the components present in inorganic solids are separated and purified. By this process impure solid or mixture is mixed with a suitable solvent and heated and at this position the solution is filterated by a suitable filter (say, funnel). After filteration the solution is cooled down and on cooling pure substance is separated in the form of crystal from the solution. The impurities of the mixture dissolve into the solution and these crystals are filtered, dried and separated.

2. Process of distillation : By the process of distillation mainly the mixture of the liquids are separated and specially those components mixtures are separated which have a substantial gap among the boiling points of the liquid mixture. In this process the component liquids are vapourised and transported to another place where these are cooled down and transformed into the liquid state. Thus liquid mixtures are separated and purified and in the entire process two processes— vapourisation and condensation are involved.

3. Process of sublimation : Normally when a solid substance is heated then it converts into liquid and on further heating this liquid is transformed into the gas, but there are certain substances (solid) which are when heated convert directly into vapours or gases and on cooling (condensation) transform into solids directly. This is called sublimation and the corresponding substance is called sublimate.

Thus by the process of sublimation the mixture of two those solids are separated and purified in which one solid is sublimate. In this process the mixture is heated in which sublimate substance is vapourised and this vapour is collected separately and ultimately cooled down. Thereby two solid substances are separated and the mixture is purified. The substances like Nefthelin, ammonium chloride, camphor Anthrasin, Benzoic acid etc. are sublimates.

(iv) Process of fractional distillation : By the process of fractional distillation those mixture of liquids are separated and purified which have a very narrow gap between their boiling points. Thus this process is applied for the mixture of those liquids which have nearly same boiling points. The composite oil from the earth's crust is extracted through which petrol, diesel, K-oil etc are separated by the process of fractional distillation. The gases components of the aqueous air are also separated by this process.

(v) Process of chromatography : This process is basically applied for those mixtures whose components have various absorption capacity and absorption is made at various distances and ultimately separated.

(vi) Process of steam distillation : By the process of steam distillation those mixtures of organic substances are separated which are insoluble in water and form the vapour. Also those organic substances are purified by this process which decompose at their respective boiling points. The organic substances (compounds) like Acetone, Acetaldehyde, Methyl alcohol etc. are purified by this process.

2. Atomic Mass Unit and Mole Concept

Atomic Mass of Unit (a.m.u.) : The $\frac{1}{12}$th part of the mass of a carbon atom (mass number 12) is called Atomic Mass Unit.

Atomic mass or Mass number : The atomic mass or mass number of an element is a number which tell us that the mass of an atom of the element is how many times heavier than the mass of $\frac{1}{12}$th part of a carbon atom (C^{12}).

Elements and their respective Atomic number and Atomic mass (mass number)

Element	Symbol	Atomic Number	Atomic Mass
Hydgrogen	H	1	1.008
Helium	He	2	4.003
Lithium	Li	3	6.940
Berilium	Be	4	9.013
Boron	B	5	10.82
Carbon	C	6	12.011
Nitrogen	N	7	14.006
Oxygen	O	8	15.999
Fluorine	F	9	19.00
Neon	Ne	10	20.183
Sodium	Na	11	22.989
Magnesium	Mg	12	24.32
Aluminium	Al	13	26.97
Silicon	Si	14	28.09
Phosphorus	P	15	30.98
Sulphur	S	16	32.064
Chlorine	Cl	17	35.453
Argon	Ar	18	39.944
Potassium	K	19	39.09
Calcium	Ca	20	40.08
Manganese	Mn	25	54.94
Iron	Fe	26	55.847
Copper	Cu	29	63.546
Zinc	Zn	30	65.38
Bromine	Br	35	79.916
Silver	Ag	47	107.880
Tin	Sn	50	118.70
Gold	Au	79	196.9665
Lead	Pb	82	207.21

Mole and Avogadro number : If in a substance there are 6.023×10^{23} atoms, molecules or ions then the substance is said to have 1 mole amount. Thus, a definite number (6.23×10^{23}) of atoms, molecules or ions of any substance represent one mole and this number is called Avogadro number. Thus in any element the number of atoms present in 1 g atom or 1 mole is 6.023×10^{23} and it is called Avogadro number.

3. Atomic Structure

In 1803 John Dalton propounded the atomic theory according to which an atom is indivisible and this concept was remained prevalent upto last of the 19th century. But later atomic models and atomic theories proved that atoms are divisible and they have a definite internal configuration and composition. The atomic models like Rutherford's model, Bohr's model, Vector's model etc has confirmed that the atoms are composed (constituted) by a number of micro particles like electron, proton and neutron etc. Other than electron, proton and neutron some more micro particles positron, mesons, neutrino etc are also present and these are appeared temporarily within the atomic nucleus in the process of micro particles exchange mechanism. These micro particles are called elementary particles or fundamental particles.

Atom and Molecule : The atom of an element is the smallest particle which takes part in chemical reaction but doesn't exist in free state in nature.

Similarly the molecule of an element or compound is the smallest particle which doesn't take part in chemical reaction but exists in free state in nature.

Main fundamental particles of the atom :

Electron : This fundamental particle was invented by J. J. Thomson in 1897 and it is a negatively charged particle which rotates in various orbits around the nucleus. The mass of an electron $= 9.1 \times 10^{-3}$ kg and the charge of an electron $= -1.6 \times 10^{-19}$ coulomb.

Proton : This fundamental particle was invented by Goldstein in 1919 and it is a positively charged stable particle. The mass of a proton $= 1.67 \times 10^{-27}$ kg and the charge of a proton $= + 1.6 \times 10^{-19}$ coulomb.

Neutron : This fundamental particle was invented by Chadwick in 1932 which is a neutral unstable particle. The masses of a proton and neutron are nearly equal.

Rutherford's Atomic model : Rutherford in 1911 conducted an experiment to detect the inner composition (configuration) of an atom and it is called Rutherford's α-particles scattering experiment. He rejected the conclusions and facts detected by Dalton regarding the atomic theory and propounded a comprehensive theory which is called Rutherford atomic model.

This model has the following conclusions :

(i) In an atom there is a central massive part and it is called nucleus which is surrounded by the electrons and in this nucleus proton and neutron are packed together.

(ii) The atom is spherical and most of its part is empty.

(iii) The size of the nucleus is very small with comparison to the entire

(iv) Rutherford predicted empirically that the electrons rotate in various orbits around the nucleus while the electron and proton of the nucleus has a coulomb force of attraction which is equal to the centripetal force to remain the electron orbiting in the circular orbits.

Shortcoming of this model : According to the classical theory of electrodynamics every accelerated electron would radiate energy continuously around the nucleus under the influence of centripetal acceleration and ultimately electron would be spiralled out into the nucleus and the atom would collapse. But the atom is found to be stable. Thus Rutherford's model could not explain about the atom stability and this model was discarded.

Bohr's Atomic model : In 1913 Neils Bohr introduced a revolutionary concept (quantum concept) to explain the stability of an atom. He asserted that the old classical laws which are applicable to macro bodies can not be directly applied on the sub-atomic particles (micro particles) like electrons or protons.

Bohr gave the following new ideas on the basis of Planck's quantum theory which is called the postulates of Bohr's theory and these are given as below:

(i) The centripetal force required for an orbiting electron is counter balanced by the electrostatical Coulombian force of attraction between the nucleus and the electron.

(ii) The electrons in an atom only revolve in a certain definite orbit in which energy is fixed and quantized. This orbit is stationary and in such orbit electron doesn't radiate any energy although it is accelerated. Only those orbits are stable in which electrons rotate and the angular momentum of such orbits must be quantized which is equal to an integral multiple of $h/2\pi$.

(iii) Electrons of greater radii posses greater energy and vice-versa. But if an electron jumps from a higher orbit to a lower one then a quanta of energy appears to be radiated, while when an electron is raised from a lower orbit to a higher orbit then a quanta of energy appears to be absorpt. Thus energy emission or absorption from the electron's orbit is not continuous but discrete and it occurs only when an electron jumps from a higher to a lower orbit and vice-versa.

Atomic Number : The number of protons or electrons of an atom of the element is called atomic number of the element and it is represented by Z. The atomic number of an element is a basic characteristic.

Obviously the nucleus of hydrogen atom has 1 proton and in the atom 1 electron exists, that's why hydrogen atom is said to have 1 atomic number. Similarly the nucleus of nitrogen has 7 protons and 7 electrons exist in the atom. Thus atomic number is 7.

Mass Number : In every atom there is a small central massive part called nucleus where almost masses of the atom is assumed to be concentrated.

The nucleus of an atom consists of proton and neutron which is collectively called nucleons. The sum of number of protons and neutrons of the nucleus of an atom of the element is called mass number and it is represented by A.

Atomic Symbol of an element : An atom X of an element can be represented by an atomic symbol given as below :

X^A where; Z = Atomic number

A = Mass number

Bohr-Burry Scheme : Bohr and Burry propounded a comprehensive plan to explain the electronic arrangements of orbiting electrons in various orbits in 1921 and it is called Bohr-Burry scheme.

According to this scheme following postulates were taken under the consideration—

(i) The maximum number of electrons in an orbit is $2n^2$; where n = orbit number.

(ii) In the outermost orbit of an atom there exists maximum 8 electrons.

(iii) Unless there are 2 electrons in the outermost orbit of an atom, there can not be more than 8 electrons in its penultimate orbit.

(iv) Unless there are 18 electrons in the penultimate orbit and 2 electrons in the outermost orbit of an atom, there can not be more than 2 electrons in its outermost orbit.

(v) More than 18 electrons are accommodated in an orbit of an atom only when its inner orbits are completely filled up and its outermost orbit contains 2 electrons and penultimate orbit contains 8 electrons.

Shell or Orbit : The electrons revolve in various orbits with different and definite energies in the atom and these orbits which are the trajectories or paths of the electrons are called shells. The inner most orbit or shell has the lowest energy and the outermost orbit or shell has the largest energy. Various shells from lower to upper are represented symbolically by K, L, M, N, O, P etc.

Subshell or Suborbit : According to a three dimensional graphic plot of electronic wave function and the internal atomic composition every shell or an orbit has a number of subshells in which various orbitals are found and these are represented by various small letters s, p, d and f. As in every orbit the number of electrons are fixed and similarly in every orbital of various subshell number of electrons are fixed. The maximum number of electrons in the orbitals s, p, d and f are 2, 6, 10, 14 respectively. It is also observed that in various shell K, L, M, N etc. there are various corresponding subshells or suborbits s, sp, spd, $spdf$ etc respectively.

Orbital : An orbital is a three dimensional space around the nucleus of an atom where there is a maximum probability of finding an electron.

Electronic Configuration : A comprehensive and proper distribution of the electrons in various shells and subshells of an atom is called electronic configuration.

Examples :

Na (11) — Electronic configuration ($1s^2$, $2s^2 2p^6$, $3s^1$)

Mg (12) — Electronic configuration ($1s^2$, $2s^2 2p^6$, $3s^2$)

Ca (20) — Electronic configuration ($1s^2$, $2s^2 2p^6$, $3s^2 3p^6$, $4s^2$)

$s \rightarrow 2e^-$
$p \rightarrow 6e^-$
$d \rightarrow 10e^-$

Valance electron and Core electron : The electron present in the outermost orbit of an atom is called valence electron. But the electron present in all the inner orbits of an atom is called core electron.

Example :

Na (11) —	(2, 8) Core electron	(1) Valance electron
Al (13) —	(2, 8) Core electron	(3) Valance electron

The relationship between valence electrons and chemicals properties of the element :

(i) The energy of valence electron in an atom is greater than the energy of core electrons.

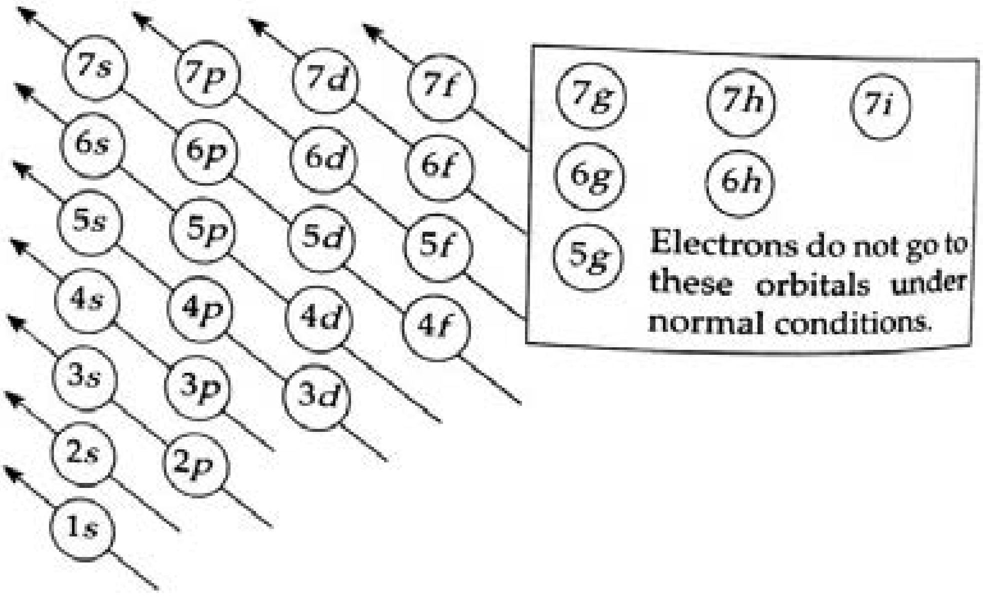
(ii) By the valence electron of the atom of an element the valency of the element is determined.

(iii) If the valence electrons of various atoms of the elements are same then there is a uniformity and resemblance in their chemical properties and vice-versa. In other words if valence electrons are different for different elements then their chemical properties are also different.

(iv) The number of valence electrons of an element is equal to the group number of the modern periodic table.

Aufbau Principle : Aufbau is a German word which means *to build.* Aufbau principle explained about the order of filling up the atomic orbitals and thus gives the principle of forming the atomic structure of the elements with the electrons. According to this principle the electrons are filled up in atomic orbitals in order of their increasing energy.

An electron occupies the orbital of lowest energy first and when it is filled up completely then remaining electrons are accommodated to the orbitals of the next higher energy. The orbital having highest energy is filled up in last. The order of filling of atomic orbitals with electrons can be shown as below ;


7s
7p
7d
7f
7g
7h
7i
6s
6p
6d
6f
6g
6h
5s
5p
5d
5f
5g
4s
4p
4d
4f
3s
3p
3d
2s
2p
1s
Electrons do not go to these orbitals under normal conditions.

Thus according to Aufbau principle the order of energy levels of various subshells —$1s < 2s < 2p < 3s < 3p < 4s < 3d < 4p < 5s < 4d < 5p < 6s < 4f < 5d < 6p < 7s < 5f$.

Quantum Numbers : The Quantum numbers are those number through which the position of electrons and their respective energies in various shells, subshells or orbitals are known.

To know the position of an electron and its corresponding energy, normally there are four parameters which are needed to describe it as given below :

(i) The orbit number in which electron exists.

(ii) The suborbit (subshell) of the orbit (shell) in which electron resides.

(iii) The orbital of the subshell in which electron resides.

(iv) The electron which rotates in the orbital.

There are four quantum numbers —

(i) Principal Quantum Number

(ii) Azimuthal Quantum Number

(iii) Magnetic Quantum Number

(iv) Spin Quantum Number

(i) Principal Quantum Number : The quantum number which simply indicates orbit number of an electron and its energy and it is represented by n (=1, 2, 3, ...), where n is integer. For $n = 1$, electron is said to be in normal state.

(ii) Azimuthal Quantum Number : The quantum number which represents the angular momentum of the revolving electron and it is indicated by l. For principal quantum number n, l has all the values from 0 to $(n-1)$.

Example :

If $n = 1$ then $l = 0$, If $n = 2$ then $l = 0, 1$

If $n = 3$ then $l = 0, 1, 2$, If $n = 4$ then $l = 0, 1, 2, 3$ etc.

(iii) Magnetic Quantum Number : The quantum number which indicates the direction of an orbit in space in a magnetic field and it is represented by m. The values of magnetic quantum number m depend on the value of l and its values are from $-l$ to $+l$ including zero.

Examples :

If $l = 0$ then $m = 0$, If $l = 1$ then $m = -1, 0, +1$.

If $l = 2$ then $m = -2, -1, 0 + 1$,

If $l = 3$ then $m = -3, -2 - 1, 0, +1, +2, +3$.

Thus the total number of the values of $m = 2l + 1$.

(iv) Spin Quantum Number : The quantum number which represents spin of the electron. Quantum mechanically it has been observed that electrons have two types of spin — clockwise (+ 1/2) and anticlockwise (– 1/2). In fact spinning electrons possess spin angular momentum and it is quantized. Thus spin quantum number has two values + 1/2 and – 1/2 and represented by s.

Quantum Number	Symbol	Contents
Principal Quantum Number	n	Orbit number and the corresponding energy of the electron.
Azimuthal Quantum Number	l	Angular momentum of the revolving electron of subshell.
Magnetic Quantum Number	m	Direction of an orbital in the space of magnetic field.
Spin Quantum Number	s	Spin of the electron.

Pauli's Exclusion Principle : After the introduction of the concept of various quantum numbers in the shells or subshells of the electrons Pauli understood the significance of the quantum numbers and put forward a rule which fixes the maximum number of electrons in an orbit.

The Pauli's exclusion principle states that—

No two electrons in an atom can have the same set of four quantum numbers and maximum a set of three quantum numbers for two electrons can be identical but the fourth quantum number must be different for them.

Thus according to this rule only following two sets of four quantum numbers are possible for the first orbit.

$$n = 1 \qquad n = 1$$
$$l = 0 \qquad l = 0$$
$$m = 0 \qquad m = 0$$
$$s = +\frac{1}{2} \qquad s = -\frac{1}{2}$$

Thus in the first orbit, only two electrons can be accommodated — one spinning in clockwise direction and other in anticlockwise direction.

Hund's rule : This is also called law of maximum multiplicity and it states that—

Electrons have a general tendency to remain unpaired in an incompletely filled orbital so as to have maximum spin multiplicity, maximum stability and minimum energy.

Isotopes : The atoms of an element which have equal atomic numbers but different mass numbers are called isotopes. The isotopes of an element have same number of protons but different number of neutrons in their respective atomic nuclei, that's why atomic number of the isotopes of element are same but mass number differ.

Example : The element hydrogen has three isotopes— protium ($_1H^1$), duterium ($_1H^2$) and tritium ($_1H^3$). Obviously these isotopes have 1 proton and 1 electron, while number of neutrons are 0, 1 and 2 respectively.

Also the element carbon has two isotopes— $_6C^{12}$ and $_6C^{14}$.

Characteristics

(i) The chemical properties of all the isotopes of an element are same but their physical properties are different.

(ii) All isotopes of an element in the periodic table have the same place.

(iii) All isotopes of an element have same number of electrons in their respective atoms.

Hydrogen is the only element in our periodic table which has three isotopes and all have their different names.

The element polonium has the maximum number of isotopes among all elements of the periodic table.

The isotope tritium (${}_1H^3$) of hydrogen has some radioactive feature.

Isobars : The atoms of an element which have equal mass numbers but different atomic numbers are called isobars. The occurrence of different atomic numbers in isobars is due to presence of different number of protons in atomic nuclei of the element.

Example : Obviously (${}_7N^{14}$) and carbon (${}_6C^{14}$) are isobars to each other because both have same mass numbers. Similarly argan (${}_{18}Ar^{40}$), potassium (${}_{19}K^{40}$) and calcium (${}_{20}Ca^{40}$) are isobars, sodium (${}_{11}Na^{24}$) and Magnesium (${}_{12}Mg^{24}$) are isobars etc.

Characteristics :

(i) The physical properties of the isobars are different, while its chemical properties always differ to each other isobars.

(ii) The physical characteristics which are directly dependent on the mass numbers are same in isobars.

(iii) Generally man made (artificial isobars) are produced by the emission of beta (β) particles from the radioactive elements.

Isotones : The atoms of an element which have atomic numbers and mass numbers both different but the number of neutrons in atomic nuclei are same are called isotones.

Example : Obviously phosphorus (${}_{15}P^{31}$) and silicon (${}_{14}Si^{30}$) are isotones to each other because each have 16 neutrons. Also vendium (${}_{23}V^{51}$) and chromium (${}_{24}Cr^{52}$) are isotones because of same number of neutrons.

Isoelectronics : The ions in which number of electrons are same are called isoelectronics.

Example : Obviously Sodium ion (Na^+), Magnesium ion (Mg^{++}) and fluorine ion (F^-) are isoelectronics because each has 10 electrons.

4. Radioactivity

Radioactivity and its invention (discovery) : Naturally occurring substances, elements and its various compounds emit certain invisible rays by the process of self disintegration is called radioactive substance and this phenomenon is called radioactivity. The invisible rays emitted from the radioactive substances are called radioactive rays. The radioactivity is a nuclear phenomenon and it occurs due to the nuclear unstability of the atoms.

Henery Bacquerel in 1896 invented the phenomenon of radioactivity and observed that through Uranium and its compound of salts certain invisible rays emit. In the early time these invisible radiations were called Bacquerel rays. Later Madam Curie and Pierre Curie asserted that the emission of invisible radiations from Uranium and its compounds are totally a nuclear phenomenon and this specific characteristic of Uranium and its compound doesn't depend upon physical and chemical parameters.

In 1898 Madam Curie and Schimide also detected that thorium and its compounds also exhibit the phenomenon of radioactivity. Again in 1902 Madam Curie and Pierre Curie observed that a miniral of Uranium called Pitch Blende whose radioactivity is nearly more than four times than Uranium. Later these Curie's Couple invented Radium from the pitch Blende which was also radioactive. All natural elements from atomic number 1 (Hydrogen) to 83 (Bismuth) are stable because their nuclei are stable. Elements from atomic number 84 (Polonium) to the last element (at. no. 105) have unstable nuclei and these are radioactive. Today about 40 natural isotopes of the elements and other compounds exhibit the characteristics of the radioactivity.

Radioactive rays and its properties : Radioactive elements and their compounds split into smaller fragments by the process of nuclear spontaneous disintegration and emit invisible radiations which were called Bacquerel rays. Bacquerel rays consists of positively charged alpha-rays (α-rays), negatively charged beta-rays (β-rays) and electrically neutral gamma-rays (γ-rays). The radioactive rays α, β and γ were pronounced their name by Rutherford.

Properties of α-rays :

(i) α-rays are the streams of He^{++} ions which have mass of 4 a.m.u. and charge of 2 units that's why α-rays are called α-particles.

(ii) When α-particles are passed through an electric field and a magnetic field then these are deflected.

(iii) It has maximum power of ionisation through the gases.

(iv) Its velocity is less than that of light and it is equal to the 1/10th of the velocity of light in vacuum (3×10^8 m/second)

(v) It has least penetrating power as compared to that of β and γ-rays.

Properties of β-rays :

(i) β-rays are streams of fast moving electrons.

(ii) Each β-particle is an electron having mass of $\frac{1}{1836}$ a.m.u. and the charge of -1 unit.

(iii) It has less power of ionisation through the gases as compared to α-rays.

(iv) Its velocity is equal to (33 – 92%) of the velocity of light.

(v) It has more penetrating power than α-rays and less penetrating power than γ-rays.

Properties of γ-rays :

(i) γ-rays are electro-magnetic radiations of high energy.

(ii) It is composed of photons (rest mass zero) of high energy.

(iii) It is electrically neutral and it is an electromagnetic wave thus it has a velocity equal to the velocity of light in vacuum (3×10^8 m/second).

(iv) It has the largest (maximum) penetrating power and it can pass through 8 cm thick lead block and 25 cm thickened iron sheet.

Types of radioactive elements : Elements which exhibit the phenomenon of radioactivity are called radioactive elements and these are of two types;

(i) Natural radioactive elements :

The elements Po (84), At (85), Rn (86), Fr (87), Ra (88), Ac (89), Th (90), Pa (91) and U (92) are naturally occurring radioactive elements.

(ii) Artificial radioactive elements : The elements Np (93), Pu (94) .... to Habnium, Ha (105) are radioactive elements which have been synthesized inside the nuclear laboratory. These are called artificial radioactive elements and also called transuranic elements.

The idea of the artificial radioactivity firstly came in the mind of F. Juliot in 1934 which was immediately supported by I. Curie. Various attempts were taken to produce radioactive elements artificially by lighter non-radioactive elements. Rutherford was working in this regard very rigorously and succeeded in disintegrating nitrogen nuclei by bombarding ordinary nitrogen gas with α-particles. Thus a nuclear reaction occurs as given below :

$$\underset{\text{nitrogen}}{{}_7N^{14}} + \underset{\alpha\text{-particle}}{{}_2He^4} \rightarrow \underset{\text{oxygen isotope (radioactive)}}{{}_8O^{17}} + \underset{\text{proton}}{{}_1H^1}$$

Thus Rutherford transformed an ordinary nitrogen into a rare isotope of oxygen. This was the first artificial (man made) radioactive element by nuclear transformation.

Out of all the radioactive elements, Radium is the most powerful radioactive element and it was discovered by Madam Curie.

Half life period of a radioactive element : Half life period of a radioactive element is the time during which half of the total number of atoms of the radioactive element disintegrate, and it is represented by $T_{\frac{1}{2}}$.

$$\text{Half life period } \left(T_{\frac{1}{2}}\right) \text{ of an element} = \frac{0.693}{\lambda}$$

where; λ is called disintegration constant or decay constant.

Characteristics of half life period :

(i) Every radioactive element has its own half life and thus different radioactive elements have different half lives.

(ii) Half life period of a radioactive element is independent of all external conditions such as temperature, pressure, mass etc.

(iii) A radioactive element can be detected by means of its half life period.

(iv) Smaller the half life period of a radioactive element, larger is its radioactivity and vice-versa.

Radioactive element	**Half life periods**
${}_{92}U^{236}$	4.51×10^9 years.
${}_{90}Th^{222}$	1.39×10^{19} years.
${}_{89}Ac^{227}$	22 years.
${}_{91}Pa^{231}$	3.48×10^4 years.
${}_{88}Ra^{226}$	1622 years.

Radioactive disintegration : Radioactive substances emit spontaneously either α-particles or β-particles and some γ-rays but both α and β-particles are never seen to be emitted simultaneously. As radioactivity is a nuclear phenomenon and its disintegration stops when unstable nuclei become stable and all the natural radioactive elements give the final product lead (Pb) as the end-product which is non-radioactive.

Rutherford-Soddy theory of radioactive disintegration : Rutherford and Soddy studied the radioactive disintegration and formulated a theory which is based on the following facts;

The radioactive emission is a characteristic of the isotope and it varies from one isotope to another of the same element. The emission occurs spontaneously and can not be speeded up or slowed down by any external factors like temperature, pressure etc. The disintegration occurs at random and which atom would disintegrate first is simply a matter of chance.

On the basis of these facts they gave a law which is called Rutherford-Soddy law of radioactive disintegration (decay) given as below :

The rate of disintegration of a radioactive element at a given instant of time is proportional to the number of atoms of the radioactive element present at the moment.

If N be the number of atoms present in a radioactive substance at any instant t and dN be the number that disintegrates in a short interval dt, then the rate of disintegration is $-\frac{dN}{dt}$ and it is proportional to N.

Thus; $-\frac{dN}{dt} = \lambda N \qquad \Rightarrow \frac{dN}{N} = -\lambda\, dt$

where λ = a constant for a given substance called decay constant or disintegration constant or radioactive constant.

On further simplification; $N = N_0 e^{-\lambda t}$

where; N_0 = Number of atoms at the begining.

This clearly indicates that the number of atoms of a given radioactive substance decrease exponentially with time (more rapidly at first and slowly afterwards). This is the reason why the radioactivity of a substance is being never zero and it will be zero only at infinite time.

Average or Mean life : The atom of a radioactive substance disintegrates constantly but which particular atom will disintegrate at any time is quite uncertain. Thus life span of every atom of a radioactive element is different. The atom which disintegrates earlier has a very short life and others disintegrating at a later have a large life. Thus to ascertain the life of a radioactive element the average life or mean life of all its atoms is taken and it is represented by T_{av}. The average life is thus defined as below ;

$$\text{Average life } (T_{av}) = \frac{\text{sum of lives of all atoms}}{\text{Total number of atoms}} = \frac{\int_0^\infty t\,dn}{\int_0^\infty dn} = \frac{1}{\lambda}$$

$\Rightarrow \; T_{av} = \frac{1}{\lambda}$ where, λ = decay constant (disintegration constant).

Units and measurement of radioactivity

There are various units of radioactivity—

Curie : The activity of 1 g of pure radium is called curie;

1 curie = 3.7×10^{10} disintegration / second (decay / second)

Rutherford : The amount of a radioactive substance which gives 10^6 disintegration per second.

$\Rightarrow$ 1 Rutherford = 10^6 disintegration / second

Bacquerel (S.I. Unit) : It is defined as the amount of a radioactive substance which gives 1 disintegration per second.

$\Rightarrow$ 1 Bacquerel = 1 disintegration / second (decay / second)

Incidently one micro rutherford equals one bacquerel mass.

Radioactivity of the radioactive substance is measured by an instrument which is called *Geiger Muller Counter.*

Radioactive Series : All the natural radioactive elements lie in the range of atomic numbers from $Z = 83$ to $Z = 92$. The nuclei of these elements are unstable and disintegrate by ejecting either an α-particle or a β-particle along with sometimes γ-rays. The ejection of an α-particle lowers the mass number A by 4, the atomic number Z by 2. The ejection of a β-particle has no effect on mass number but increases the atomic number by 1. The atomic number is the characteristic of an element and a change in it implies the formation of an atom of a new element. The new atom so formed is also radioactive and further disintegrates into another new atom and so on. Thus a series of new radioactive elements is produced by successive disintegration until a stable element is obtained. Such a series is called radioactive series.

There are four important radioactive series - (*UTAN*) Uranium series, Thorium series, Actinium series and Neptunium series.

Soddy-Fajan's group displacement laws : Every radioactive substance emits either an α-particle or a β-particle and often some γ-rays. The emission of these radiations change the original nucleus (called parent nucleus) to a new nucleus (called daughter nucleus).

Soddy-Fajan's group displacement law states that the emission of one α-particle reduces the mass number by 4 units and atomic number by 2 units, while the emission of one β-particle is caused by the decay of a neutron into proton and atomic number in its emission is increased by 1 unit and mass number remains same. The emission of γ-rays do not affect the mass number and atomic number but its emission changes the nucleus from an excited state (high energy state) to a less excited (lower energy state) state

Example :

$$_{88}Ra^{226} \xrightarrow[\text{emission}]{\alpha\text{-particle}} {}_{86}Rn^{222} \xrightarrow[\text{emission}]{\beta\text{-particle}} {}_{87}Fr^{222} \xrightarrow[\text{emission}]{\beta\text{-particle}} \underset{\text{more excited state}}{_{88}Ra^{222}} \xrightarrow[\text{emission}]{\gamma\text{-ray}} \underset{\text{less excited state}}{_{88}Ra^{222}}$$

Radioactive dating or Radio isotope dating : Naturally occurring radioactive isotopes have been very useful in dating (estimating age) the geological events. Thus the technique of detecting the amount or quantity of a radio isotope in the sample of the rock, dead plants or organism or in a bio residue to estimate (measure) its actual (exact) age is called Radioactive or radio isotope dating.

Carbon dating is one of the best example of a radio isotope dating The idea of carbon dating was suggested by Prof. Libby a Nuclear physicist of Chicago. Our atmosphere has a large number of stable isotopes. When cosmic rays strike these isotopes a number of radio isotopes are produced. One of these radio isotopes is carbon –14 ($_6C^{14}$) which is produced by the bombardment of atmospheric nitrogen with a high energy neutron.

$$_7N^{14} + {}_0n^1 \rightarrow {}_6C^{14} + {}_1H^1.$$

Radio carbon ($_6C^{14}$) is unstable and decays (by emitting β-particle) into nitrogen which has a half life period of 5600 years. By measuring the ratio of the concentration of $_6C^{14}$ to $_6C^{12}$ of an ancient organism like fossil, dead tree or plant one can measure (estimate) the exact age.

The ages of non-living ancient geological substances like old rocks, earth etc are estimated by the use of uranium or its most suitable mineral pitch blende in which both uranium and thorium are found. This technique is called uranium dating. But for the most ancient geological rocks Potassium-Argan dating technique is used.

Applications of radio-isotopes : At present the radio-isotopes are used in every walk of our life. Some most important applications of these radio-isotopes are—

1. The radio-isotopes are used in the form of tracer in medicines and by the Tracer technique tumours (unwanted growth of cells) in human body are detected.
2. The leakage in the pipe (tube) planted for the flow of underground water or oils are today detected by the use of radio-isotopes.
3. The cancerous cells are destroyed completely by the use of radio-isotopes. For example, cobalt-isotope ($_{27}Co^{60}$) is today frequently used in the therapy of cancer and in destroying brain tumours. The element radium (Ra) has been used for burning and destroying cancerous cells.
4. The radio-isotope (radio sodium) is used to detect any residue or unwanted circulatory system.
5. The radio-phosphorus is used today in curing bone diseases.

6. The radio-iodine is used to detect any side effect appears inside the thyroid gland.
7. The radio-sodium is used to measure the speed of blood flow in the human body.
8. The radio-iron is used to detect the disease like anaemia, tuberculosis and other malnutrient diseases.
9. The radio-uranium (${}_{92}U^{238}$) is used to estimate the age of the earth.
10. Mutation occurs in plants and seeds with intense radioactive radiation, resulting in the development of new and improved plants. More effective insecticides have also been developed with the help of radio-isotopes.

Nuclear energy : Due to the nuclear transformation in any radioactive substance there is always a loss in mass which appears in the form of nuclear energy. Thus nuclear energy is produced by the simple conversion of lost mass into the energy by Einstein's mass energy equivalent relation $\Delta E = \Delta mc^2$, where c = velocity of light in vacuum.

There are two sources of nuclear energy ;

(I) Nuclear Fission

In 1939 two German scientists—Otto Hahn and Fritz Strassman discovered a strange and new type of nuclear reaction. They found that when Uranium nucleus (${}_{92}U^{235}$) is bombarded with a slow neutron, the nucleus splits up into nearly two equal fragments with the release of some free neutrons and tremendous energy of about 200 MeV per ${}_{92}U^{235}$ nucleus. Such a nuclear reaction was termed as nuclear fission.

Thus the process (nuclear reaction) in which a heavy nucleus splits up into two nuclei of nearly comparable masses with tremendous release of energy and some free neutrons is called nuclear fission. Elements having a higher value of neutron to proton ratio are more likely to undergo fission.

Neutron induced fission of uranium is represented as below :

$$\underset{}{{}_{92}U^{235}} + \underset{\text{(Slow neutron)}}{{}_{0}n^{1}} \rightarrow \underset{\text{(compound nucleus)}}{({}_{92}U^{236})} \rightarrow {}_{56}Ba^{141} + {}_{36}Kr^{92} + 3\,{}_{0}n^{1} + 200\text{ MeV.}$$

The average number of neutrons released in a uranium atom fission is 2.5. These neutrons produced in nuclear fission under favourable circumstances cause further atoms of uranium to undergo fission and in turn emit more neutrons which will cause further fission explosion. Thus a chain reaction is established in a short time releasing enormous sum of energy. One gm of ${}_{92}U^{235}$ evolves upon fission about 2×10^7 kilo-calorie of energy.

Types of nuclear fission : Fission chain reaction is of two types, namely;

1. Explosive or uncontrolled chain reaction.
2. Controlled chain reaction.

1. Explosive or uncontrolled chain reaction : A nuclear chain reaction in which fission neutrons keep on increasing till the whole of fissionable material is consumed is called explosive or uncontrolled chain reaction.

Such a process (reaction) proceeds very quickly with the liberation of tremendous amount of fission energy in a very short span of time. The atom bomb is a practical example of explosive or uncontrolled fission. The nuclear fission is used in the manufacturing of atom bomb using U^{235} isotope. The first atom bomb (nuclear bomb) was dropped on the two cities of Japan— Hiroshima and Nagasaki in August 1945 by USA during 2nd world war. These two industrial cities Hiroshima and Nagasaki completely destroyed by high explosion and radioactive fall out of α, β and γ-rays.

2. Controlled chain reaction : A fission chain reaction which proceeds slowly without any explosion and in which the energy released can be controlled is called controlled chain reaction.

The nuclear reactor is a practical example of controlled chain reaction. In the nuclear reactor the energy released through the fission is used to generate the electricity.

Basic components of a nuclear reactor

(i) Nuclear fuels : The elements used to activate the controlled fission in the nuclear reactors are called nuclear fuels. Some common nuclear fuels are uranium isotopes – U^{233}, U^{235}, thorium isotope –Th^{232} and Plutonium isotope – Pu^{239} etc.

(ii) Moderators : Moderators are used to slow down the emitted neutrons. Heavy water, graphite, beryllium, beryllium oxide, some organic liquids etc. are used as moderators. But heavy water is the best moderator because of its very small cross section and larger slowing down power capacity.

(iii) Coolant : A coolant removes the tremendous heat developed in the reactor core. This heat is evolved from the K.E. of the fission fragments when these are slowed down in the fissionable substance and moderator. Through a heat exchanger, the coolant transfers heat to the secondary thermal system of the reactor. Water, steam, helium, CO_2, air, molten metals etc. are used as coolants.

(iv) Control rods : To start and stop a fission reaction, control rods are used. Due to large absorption cross-section area Cadmium are Boron rods are used as control rods. When control rods are inserted in the reactor unit they absorb the neutrons and chain reaction ceases.

(v) Radiation protective arrangement : In the nuclear reactor large amount of penetrating radiations like γ-rays, in addition to neutrons are also generated. These radiations pose danger to the technicians working around a reactor. Hence a reactor is always surrounded by a thick shield in the form of a concerete wall many metres thick (lined with lead) to absorb these radiations and prevent them from leaking out into the adjacent area.

Nuclear reactors in India : The first nuclear reactor in all over the world was built by an Italian nuclear physicist Enrico Fermi in Chicago university at USA in 1942. In India the first nuclear reactor was built in 1956 at Trombay and it is a *swimming pool* reactor with U^{235} rods hanging in a tank containing heavy water. Other nuclear reactors are Cerus, Zerlina Purnima and R-5 at Trombay.

(II) Nuclear Fusion : The process of combining two light nuclei to form a heavy nucleus with tremendous release of energy is known as nuclear fusion.

Similar to fission, in fusion an appearance of small mass difference takes place between the reactants and product and this mass difference transforms into nuclear energy by Einstein's mass energy equivalence relation; $\Delta E = \Delta mc^2$. Also like nuclear fission, in fusion lighter nuclei such as hydrogen, deutron, tritium and helium etc are involved. A typical nuclear fusion reaction occuring in sun is given as below :

$$_1H^1 + {}_1H^1 + {}_1H^1 + {}_1H^1 \rightarrow {}_2He^4 + 2e^+ + 24.7 \text{ MeV.}$$

The main difficulty in carrying out the fusion reaction is that when two light nuclei are brought together, they strongly repel each other due to the identical nature of charges on them. Thus for the occurrence of the fusion, the *K.E.* of colliding nuclei must be high enough to overcome this repulsion. The order of this energy is about 0.1 MeV.

To impart energies to nuclei as high as 0.1 MeV, the temperature would have to raised to about 10^6K. Without achieving the temperature of this order nuclear fusion is not possible and that's why, the fusion is also called thermo-nuclear reaction. At temperature of this order the fusion materials are found in an ionised state and behave like a swirling mass of high density and it is called plasma. At present the plasma is now assumed as fourth state of matter. The fusion is the source of stellar energy (energy released by sun and other stars). Sun is radiating energy at a rate of about 10^{26} Joule / second and thus losing about 4×10^6 tonnes of matter / second. Owing to very large mass (nearly 10^{30} kg) sun will continue to exist for several billion years.

The hydrogen bomb is a practical example of the nuclear fusion. The hydrogen bomb is about 1000 times more powerful than the atom bomb of same mass which is based on nuclear fission. The essential conditions for the operation of hydrogen bomb are extremely high temperature and pressure required for the fusion to start. Once started, the fusion itself maintains the temperature to keep the process going on and for this purpose the atom bomb is used as a primer. By exploding the atom bomb the high temperature and high pressure is achieved which is necessarily required for the successful working of the hydrogen bomb.

5. Electronic theory of valency & Chemical bonding

Electronic theory of valency : This theory of valency is based the electronic structures of the elements and hence it is called electronic theory of valency. According to this theory, inert gases like Neon (Ne), Argon (Ar), Krepton (Kr), Xenon (Xe) and Redon (Rn) except Helium (He) do not exhibit valency because they contain a set of eight electrons called octet and their valencies are said to be zero. This makes their electronic structures very stable and do not take part in any chemical reaction. That's why also inert gases are found to be in free state and these are monoatomic. Helium (He) contains two electrons in the first orbit of its atom. Hence its first orbit is completely filled up and its structure is therefore also very stable. Consequently inert gases atoms have highest ionization potential than all other elements. They have zero electron affinity. Hence, they exhibit no tendency to lose or gain or share electrons and do not generally exhibit valency.

However, other elements do not contain a set of 8-electrons in the outermost orbit of their atoms. Hence their electronic structures are less stable than those of inert gases. As result of this, they exhibit a general tendency to complete a set of 8-electrons (Octet) in their outermost orbit by losing or gaining or sharing electrons and thus they exhibit valency.

Examples :

(i) Na (11) $\longrightarrow$ $Na^+ + e^{-1} \Rightarrow$ valency of Na = 1
2, 8, 1 (2, 8)

(ii) Mg (12) $\longrightarrow$ $Mg^{+2} + 2e^{-1} \Rightarrow$ valency of Mg = 2
2, 8, 2 (2, 8)

(iii) Cl (17) $+ e^{-1} \longrightarrow$ $Cl^{-1} \Rightarrow$ valency of Cl = 1
2, 8, 7 (2, 8, 8)

(iv) O (8) $+ 2e^{-1} \longrightarrow$ $O^{-2} \Rightarrow$ valency of O = 2
2, 6 (2, 8)

Ions : The electrified or electrically charged atoms or a group of atoms is called ions. Examples ; Na^+, Mg^{++}, CO_3^{--}, Cl^{-1}, SO_4^{--} etc.

There are two types of ions— Cations and Anions.

Cations : The ions which have positive charges are called cations. Examples ; Na^+, Mg^{++}, Al^{+++} etc.

Almost all metallic elements are cations, while H^+ and NH_4^+ cations are made from non-metals. When one or more electrons are ejected from the atom then cations are formed.

Anions : The ions which have negative charges are called anions. Examples ; Cl^-, O^{--}, SO_4^{--}, CO_3^{--} etc. Almost all non-metallic elements are anions.

Generally, the atoms of metallic elements by losing one or more electrons form cations and so these are called electropositive element. While the atoms of non-metallic elements by gaining one or more electrons form anions and so these are called electronegative elements.

Valency : The word valency orginates from the latin word valentia which implies - capability. Thus the capacity of the mutual combination of the atoms of the elements to each other is called valency. In otherwords the atoms of the element by losing or gaining electrons in order to achieve stability by completing octet is called valency, and it is equal to the number of electrons lost or gained. Thus the valency of an element depends on the number of electrons present in outermost orbit of the atom.

Example :

(i) Na (11) $\longrightarrow$ $Na^+ + e^{-1}$. Thus valency of sodium = 1
2, 8, 1 (2, 8)

(ii) O (8) $+ 2e^{-1} \longrightarrow$ O^{-2}. Thus valency of oxygen = 2
2, 6 (2, 8)

Chemical bonding : The binding force of the constituents atoms of the molecule to maintain a mutual atomic order and a definite but specific geometrical shape is called chemical bonding.

Types of chemical bonding : There are three types of chemical bonding— Electrovalent or Ionic bonding, covalent bonding and Co-ordinate covalent bonding.

Electrovalent or Ionic bonding : The bond formed by the result of the electron transfer from the one atom to another among the atoms is called electrovalent or ionic bonding. The transfer of electrons takes place in such a way that ions obtained after electron transfer has a configuration of an inert gas electronic structure.

Example : $\underset{2,\,8,\,1}{Na} + \underset{2,\,8,\,7}{Cl} \longrightarrow \underset{(2,\,8)}{Na^+} \quad \underset{(2,\,8,\,8)}{Cl^-} \quad (NaCl)$

Here, one electron is donated by sodium and accepted by chlorine and both Na^+ and Cl^- completed Octet and thus sodium chloride (NaCl) or ionic compound is formed.

Characteristics of electrovalent compounds : The chemical compounds whose molecules are bounded by electrovalent (ionic) bonding are called electrovalent (ionic) compounds. The examples of these compounds are— NaCl, $MgCl_2$, CaO etc. and these have following characteristics;

(i) These compounds have high m.p. and b.p. because of the presence of strong intermolecular forces of attraction in their solid states.

(ii) These compounds are non-volatile because of their high m.p. and b.p.

(iii) These compounds are generally soluble in water because they generally ionise in water, ions become heavily hydrated and they disappear in the intermolecular spaces of water molecules and dissolve.

(iv) In aqueous solution they get ionised like following ;

$NaCl \xrightarrow{\text{water}} Na+ Cl^-$ (two ions)

$K_2SO_4 \xrightarrow{\text{water}} 2K^+SO_4^{--}$ (four ions)

(v) These compounds in the solid state are made of the oppositely charged ions but the ions are held together by the stronger electrostatical forces of attraction. Hence the ions are not mobile and thus ionic compounds are bad conductor of electricity in solid state. But their aqueous solutions are good conductors of electricity, because the ions become mobile in the solution.

(vi) The fused state of these electrovalent (ionic) compounds are also good conductor of electricity, because ions become mobile and they can carry electricity across the fused mass. Thus electrovalent compounds are good electrolytes in the aqueous solutions and in fused state.

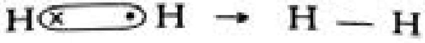
(vii) These electrovalent compounds are insoluble in organic solvents, because the organic solvents are covalent compounds.

(viii) When a large number of molecules of an electrovalent (ionic) compound join to form a crystal, the unit cell of the crystal has a definite shape.

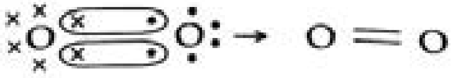
Covalent bonding : The bond formed by the result of the sharing of the electrons between two atoms in which atoms form the chemical bonding in such a way that formed molecules achieve a permanent electronic structure of the inert gas, is called covalent bonding.

Example :

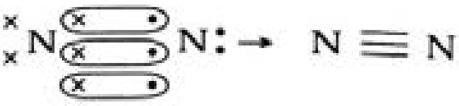
(i) When a pair of electron is produced by electrons sharing in a hydrogen molecule by two hydrogen atoms then a single covalent bond is formed.



(ii) When two pairs of electron are produced by sharing of electrons in an oxygen molecule by two oxygen atoms then a double covalent bonds are formed.



(iii) When three pairs of electron are produced by the sharing of electrons in a nitrogen molecule by three nitrogen atoms then a triple covalent bonds are formed.



Characteristics of covalent compounds :

(i) All covalent compounds are found either in the state of gas or liquid or in the form of volatile solid.

(ii) These compounds have low m.p. and b.p. because of weaker intermolecular forces among the atoms with comparison to the electrovalent (ionic) compounds.

(iii) The covalent compounds are insoluble in water but soluble in organic solvents.

(iv) The covalent compounds in the liquified state or in the form of its solution are bad conductor of electricity because in these states they don't produce any ions. But covalent compounds like HCl, NH_3 etc in the form of their aqueous solution conduct electricity because of the presence of ions.

(v) All covalent compounds exist in their molecular forms and these compounds take part very slowly in the chemical reactions with another covalent compounds.

Covalency : The covalency of an atom in a covalent compound is number of electrons which are supplied by that atom for sharing the electrons of the another atom.

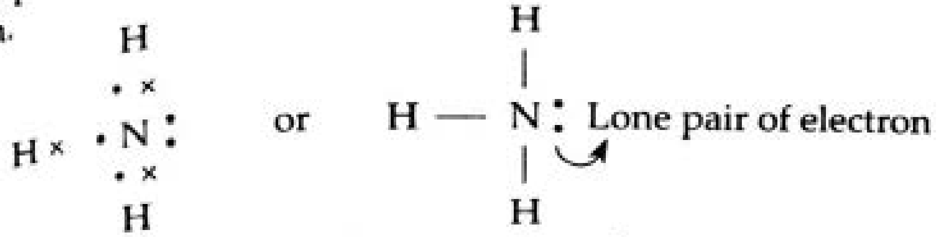
Example : In H_2 (H – H), the covalency of hydrogen is 1, in O_2 (O = O) the covalency of oxygen is 2, in CH_4 the covalency of carbon is 4.

Co-ordinate covalent bonding : In co-ordinate covalent bonding the pair of electrons are obtained by only through single atom and in this bonding the atom which supplies electrons pair is called donor and the atom which takes such pair of electrons is called acceptor. The electrons pair donated by the donor atom is called singlton pair.

Usually co-ordinate covalent bonding is represented by an arrow (→). Here a convention is followed in which a +*ve* charge (S^+) is given to the donor atom and a –*ve* charge (S^-) on the acceptor atom.

Example : To form ions like carbonate ion (CO_3^{--}), ammonium ion (NH_4^+) etc are the examples of co-ordinate covalent bonding.

Lone pair of electron : The pair of electrons which doesn't take part in sharing process of electrons in covalent bonding is called lone pair of electron.



Obviously in ammonia (NH_3), nitrogen atom has a pair of electrons which doesn't take part in sharing.

Compounds having both ionic and covalent bondings : There are certain chemical compounds which have both ionic as well as covalent bonding.

Examples : The chemical compounds like sodium hydroxide (NaOH), hydrogen cyanide (HCN), Sulphuric acid (H_2SO_4), calcium carbonate ($CaCO_3$) etc. have both ionic and covalent bondings.

Covalent compounds and their shapes :

Covalent compounds	Geometrical shape	Angle of bonding
Carbon dioxide	collinear	180°
Water	angular	104.5° (105°)
Ammonia	pyramid	109°
Methane	tetrahedral	109°28′
Ethelyne	planar	120°
Acetelyne	collinear	180°
Carbon tetrachloride	tetrahederal	109°28′
Phosphorus pentachloride	triangular bipyramid	120°90′
Sulphur hexachloride	octahedron	90°
Hydrogen sulphide	angular	92°
Sulphur dioxide	angular	119.5°
Phosphine	pyramid	107.5°
Cupromonium ion	squared coplanar	90°

6. Oxidation - Reduction

Oxidation : The oxidation is a chemical process in which either the ratio of electronegative atoms or radicals of an element or a compound increases or the ratio of electropositive atoms or radicals of the element or compound decreases.

Example : $2Mg + O_2 \longrightarrow 2MgO$, $C + O_2 \longrightarrow CO_2$.
$2H_2 + O_2 \longrightarrow 2H_2O$, $2FeCl_2 + Cl_2 \longrightarrow 2FeCl_3$.

Reduction : The reduction is a chemical process in which either the ratio of electropositive atoms or radicals of an element or a compound increases or the ratio of electronegative atoms or radicals of the element or compound decreases.

Example : $Cl_2 + H_2S \longrightarrow 2HCl + S$.
$2FeCl_3 + H_2 \longrightarrow 2FeCl_2 + 2HCl$.

Definition of oxidation and reduction on the basis of ionic theory:

Oxidation : The oxidation is a chemical process in which either positive charges increase or negative charges decrease on the ions.

Example : $FeCl_2 \longrightarrow FeCl_3$

$\Rightarrow$ $Fe^{++} + Cl^- + Cl^- \longrightarrow Fe^{+++} + Cl^- + Cl^- + Cl^-$.

Reduction : The reduction is a chemical process in which either positive charges decrease or negative charges increase on the ions.

Example : $SnCl_4 \longrightarrow SnCl_2$.

$\Rightarrow$ $Sn^{++++} + 4Cl^- \longrightarrow Sn^{++} + 2Cl^-$.

Definition of oxidation and reduction on the basis of electronic theory:

Oxidation : The oxidation is a chemical process in which atoms or ions transform themselves by lossing one or more electrons and ultimately come to a high electropositive state or a low electronegative state.

Example : $2Mg + O_2 \longrightarrow 2Mg^{++} O^{2-}$

$2FeCl_2 + Cl_2 \longrightarrow 2FeCl_3$

$(Fe^{++} + 2Cl^{-1}) \quad (Fe^{+++} + 3Cl^-)$

Reduction : The reduction is a chemical process in which atoms or ions transform themselves by gaining one or more electrons and ultimately come to a low electropositive state or a high electronegative state.

Example : $2Na + Cl_2 \longrightarrow 2NaCl$.

Oxidising and Reducing agents : The substance in which reduction occurs is called oxidising agent, while the substance in which oxidation occurs is called reducing agent. Thus the oxidising agent is a substance which gains electron, while the reducing agent is a substance which losses electron.

Example : The element or compounds like Oxygen (O_2), Ozone (O_3) Hydrogen peroxide (H_2O_2), Nitric acid (HNO_3), Potassium permangnet $(KMnO_4)$, Potassium dichromate $(K_2Cr_2O_7)$, Lead oxide (PbO_2) etc are oxidising agents, while the elements or compounds like hydrogen (H_2) hydrogen sulphide (H_2S), Carbon monoxide (CO), Sulphur dioxide (SO_2) Carbon (C), Hydradiode acid (HI), Stanous chloride $(SnCl_2)$ etc. are reducing agents.

The dual nature (Oxidising agent as well as reducing agent) of the **substance :** There are certain substances which behave like an oxidising agent as well as a reducing agent.

Examples : The compounds like Hydrogen sulphide (H_2S), Sulpher dioxide (SO_2), nitrous acid (HNO_2) etc. are used as both oxidising agent and reducing agent.

Oxidation Number : The oxidation number of an element is a number which indicates the degree of oxidation or reduction suffered by the element.

Characteristics :

(i) The oxidation number of all elements in the elemental state is zero because of lack of oxidation or reduction

The oxidation number of elements in the following molecules is zero;

Na	Cu	Fe	Ag	Au	P_4	S_8	Cl_2	I_2
0	0	0	0	0	0	0	0	0

(ii) The oxidation number of an element in a compound is equal to its valency

Examples : $Na^{+1}Cl^{-1}$, $Fe^{+3}Cl_3^{-1}$, $Cu^{+2}Cl_2^{-1}$.

The oxidation number of a metal is positive, while that of a non-metal is negative in a compound.

(iii) The sum of oxidation numbers of all atoms in a molecule is zero.

Examples : NaCl

$$\left.\begin{array}{l} Na = +1 \\ Cl = -1 \end{array}\right\} \text{Sum} = 0$$

$Ca_3(PO_4)_2$

$$\left.\begin{array}{l} 3Ca = 2 \times 3 = 6 \\ 2P = 2 \times 5 = 10 \\ 8O = 8 \times (-2) = -16 \end{array}\right\} \text{Sum} = 0$$

(iv) If a compound contains two non-metals, then the more electronegative element is assigned a negative oxidation number and the less electronegative element is assigned a positive oxidation number.

Examples : SO_2

$$\left.\begin{array}{l} 2O = 2 \times (-2) = -4 \\ S = +4 \\ S^{+4}O_2^{-2} \end{array}\right\} \text{Sum} = 0$$

PCl_5

$$\left.\begin{array}{l} P = +5 \\ 5Cl = 5 \times (-1) = -5 \\ P^{+5}Cl_5^{-1} \end{array}\right\} \text{Sum} = 0$$

(v) The sum of oxidation numbers of all atoms in an ion is equal to the charges of the ion.

Examples : ion FeS_2^{-2}

$$\left.\begin{array}{l} 2S = 2 \times (-2) = -4 \\ Fe = +2 \end{array}\right\} \text{Sum} = -2$$

(vi) The oxidation number of oxygen in a peroxide is equal to – 1.

Example : H_2O_2

$$\left.\begin{array}{l} 2H = 2 \times 1 = 2 \\ 2O = 2 \times (-1) = -2 \end{array}\right\} \text{Sum} = 0$$

In all chemical compounds oxygen has an oxidation number – 2 but in metal peroxides it has an oxidation number equal to – 1.

Explanation of Oxidation, reduction on the basis of oxidation number : The oxidation is a chemical process in which the value of the oxidation number of the atom is increased while the reduction is a chemical process in which the value of the oxidation number of the atom is decreased.

Example : $\overset{0}{F_e} + 2HCl^{+1} \longrightarrow FeCl_2^{+2} + \overset{0}{H_2}$.

Here obviously the oxidation number of iron (Fe) has been increased from 0 to + 2, while the oxidation number of hydrogen (H_2) has been decreased from +1 to 0. Thus in the above chemical reaction there is an occurrence of oxidation in iron (Fe) and an occurrence of reduction in hydrogen (H_2).

Here we can also define oxidising agent and reducing agent in the following ways ;

The oxidising agent is that substance which increases the oxidation number of the another substance, while the reducing agent is that substance which decreases the oxidation number of the another substance.

This concludes that the substance whose oxidation number increases that becomes oxidised and it is a reducing agent, while the substance whose oxidation number decreases that becomes reduced and it is an oxidising agent.

7. Acid, Base and Salt

Old Concept of Acid :

Acid : An acid is a compound which contains replaceable hydrogen atom or atoms, a part or whole of which can be replaced by means of a metal or a positive radical.

Examples : HCl, HNO_3, H_2SO_4 etc. are acids because they contain replaceable hydrogen atom or atoms.

Characteristic properties :

(i) Acids taste sour.

(ii) Acids turn blue litmus and methyl orange red.

(iii) Acids react with base and alkali to form salt and water.

$$\underset{\text{(Acid)}}{HCl} + \underset{\text{(Base)}}{NaOH} \longrightarrow \underset{\text{(Salt)}}{NaCl} + \underset{\text{(Water)}}{H_2O}.$$

(iv) Acids (strong) like HCl, HNO_3, H_2SO_4 etc are good conductors of electricity in their aqueous solutions.

(v) Acids liberate H_2 gas from metals.

(vi) Acids liberate CO_2 from carbonate, brown fumes of NO_2 from nitrite, SO_2 from sulphite and H_2S from sulphide.

Modern concepts of Acids

(i) Arrhenius's Ionic theory : According to this theory acid is the substance which provides hydrogen ion (H^+) on dissolving in water.

Examples : $HCl + H_2O \text{ (water)} \rightleftharpoons H^+ + Cl^-$.

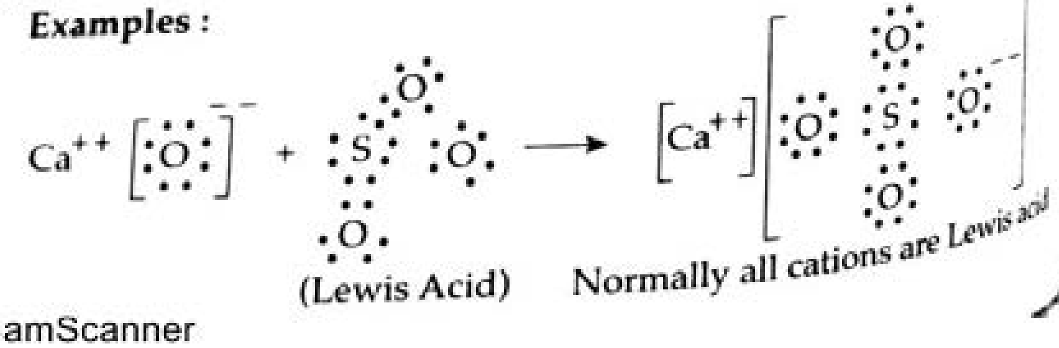
$$H_2SO_4 + H_2O \text{ (water)} \rightleftharpoons 2H^+ + SO_4^{--}.$$

(ii) Bronsted and Lowry theory : According to this theory acid is the substance which provides proton to another substance.

Examples : $HNO_3 \rightleftharpoons H^+ + NO_3^-$. $CH_3COOH \rightleftharpoons H^+ + CH_3COO^-$

(iii) Lewis's electronic theory : According to this theory acid is the substance (molecule, ion or radical) which has a tendency to accept a lone pair of electrons.

Examples :



(Lewis Acid) Normally all cations are Lewis acid

Classification of Acids—

(I) Oxy Acids : The acids which have hydrogen and oxygen both are called oxy acids.

Examples : The acids like H_2SO_4, H_3PO_4, HNO_3 etc. are examples of oxy acids.

(II) Hydra Acids : The acids which have hydrogen only but in it oxygen is absent are called hydra acids.

Examples : The acids like HCl, HBr, HCN etc. are examples of hydra acids.

Uses of Acids : (i) Uses of sulphuric acid (H_2SO_4) : The acid H_2SO_4 is used in petroleum exploration, in the preparation of various types of explosives, in the preparation of colours and medicines and in the construction of accumulated batteries.

(ii) Uses of nitric acid (HNO_3) : The acid HNO_3 is used in the preparation and manufacturing of medicines, drugs and fertilisers. This is also used in photography, in the preparation of explosives and in the preparation of aquaregia. HNO_3 is also used in laboratory as a reagent.

(iii) Uses of hydrochloric acid (HCl) : The acid HCl is used as a reagent in the laboratory, in the preparation of aquaregia and in the manufacturing of dyes, colour and drugs etc.

(iv) Uses of Acetic acid (CH_3COOH) : This acid is used as solvent, used in the preparation of vinegar, in the preparation of acetone and in the processing of sour food stuffs etc.

(v) Uses of Formic acid (HCOOH) : This acid is used in the manufacturing of insecticides, as a preservator of green fruits, in the processing of rubber, in leather industries etc.

(vi) Uses of Oxallic acid (HOOC—COOH) : This acid is used in photography, in the colouration and printing of the cloths, in the bleaching of leather, in removing ink spot from the cloth.

(vii) Uses of benzoic acid (C_6H_5COOH) : This acid is used as a perservator of medicines and food stuffs.

(viii) Uses of Citric acid ($C_6H_8O_7$) : This acid is used in washing metals, in the processing of food stuffs and drugs, in cloth industries etc.

Old Concept of Base

Base : Bases are the compounds of metals or the radicals of the metallic resemblance, which react with acids and form salt and water. Basically bases are the oxides and hydroxides of metals.

Examples : The compounds like Na_2O, Na_2OH, KOH, MgO etc. are the bases.

The oxides and hydroxides of alkali metals and alkaline earth metals are strong bases, while oxides and hydroxides of other metals are weak bases.

The water soluble bases are called alkalies.

Modern concepts of Base

(I) Arrhenius's Ionic Theory : According to this theory base is a substance whose aqueous solution provides hydroxide ion (OH^-).

Examples : $NaOH + H_2O \text{ (water)} \rightleftharpoons Na^+ (aq) + OH^- (aq)$

$NH_4OH + H_2O \text{ (water)} \rightleftharpoons NH_4^+ (aq) + OH^- (aq)$

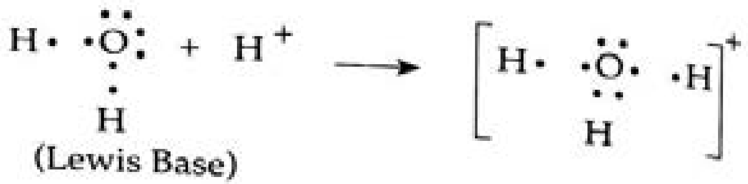
(II) Bronsted Lowry theory : According to this theory base is a substance which accepts proton from another substance.

Examples : $H^+ + OH^- \rightleftharpoons H_2O$

$H^+ + CH_3COO^- \rightleftharpoons CH_3COOH$ (Acetic acid)

(III) Lewis's electronic theory : According to this theory base is a substance (molecule, ion or radical) which has a tendency to provide a lone pair of electrons.

Example :



Characteristics :

(i) Bases are bitter in taste and their solutions are soapy in touch.

(ii) Bases turn red litmus blue and turn methyl orange yellow.

(iii) Bases react with acids and form salt and water.

(iv) Strong bases like Na_2O, NaOH, K_2O, KOH etc. are good conductors of electricity in aqueous solution and fused state hence these are good electrolyte.

(v) The oil and sulphur dissolve in bases.

(vi) Bases like oxides and hydroxides of Zn, Al, Sn, Pb, Cr, As, Sb etc dissolve in acids as well as in hot concentrated NaOH and KOH solutions which are called amphoteric.

Types of Bases :

(I) Water soluble bases : The bases soluble in water is called alkali. The bases like NaOH, KOH, $Ca(OH)_2$, NH_4OH etc. are examples of alkali.

(II) Water insoluble bases : The bases insoluble in water like CuO, Fe_2O_3, BaO, $Fe(OH)_2$ etc. react with acids and form salt and water like alkali but do not exhibit the other characteristics.

Uses of bases and alkalis

(i) Uses of calcium hydroxide [$Ca(OH)_2$] : The base $Ca(OH)_2$ is used in house whitewashing, in the preparation of concrete and plaster, in the production of bleaching powder, in softening water, in removing hair from the outer layer of the leather, in removing acidity from the soil etc.

(ii) Uses of caustic soda (NaOH) : The base (alkali) NaOH is used in the manufacturing of soap, in the purification of petroleum, in the production of cloth and paper, in the manufacturing of drugs, in the cleaning of houses and factories etc.

(iii) Uses of Potassium hydroxide (KOH) : The base (alkali) KOH is used as a reagent in the laboratory, in the production of soft soap, as an absorber of the gases like CO_2 and SO_2 etc.

(iv) Uses of Calcium oxide (CaO) : The base CaO is used in the form of concrete of the under construction houses, in the manufacturing of caustic soda (NaOH), in the production of bleaching powder etc.

(v) Uses of magnesium hydroxide [Mg $(OH)_2$] : The base $Mg(OH)_2$ is used in removing acidity from human body, in the form of Antidote due to acidic poisoning, in sugar industries etc.

(vi) Uses of magnesium oxide (MgO) : The base MgO is used as supplement of rubber, in the manufacturing of drugs etc.

Salt : A salt is a compound formed by partial or complete replacement of the replaceable hydrogen atom or atoms present in an acid molecule by means of a metal or a radical which acts like a metal.

Examples : $HCl + NaOH \longrightarrow NaCl\ (Salt) + H_2O.$

$HNO_3 + KOH \longrightarrow KNO_3\ (Salt) + H_2O.$

$H_2SO_4 + NH_4OH \longrightarrow NH_4HSO_4\ (Salt) + H_2O.$

Classification of salts :

(i) Normal Salt : A normal salt is a salt formed by the complete replacement of replaceable hydrogen atoms from an acid molecule by means of a metal or a group of elements acting like a metal.

Examples : The compounds like KCl, NaCl, $FeSO_4$, Na_2SO_4, $FeCl_2$ etc are normal salts. Obviously a normal salt doesn't contain replaceable H-atom in its molecule.

(ii) Acid Salt : An acid salt is that which contains one or more replaceable hydrogen atoms in its molecule and is formed by a partial replacement of *H*-atoms present in an acid molecule by means of a metal or a positive radical.

Examples : The compounds like $NaHSO_4$, $NaHCO_3$, $KHCO_3$, NaH_2PO_4 etc are acid salts.

(iii) Basic Salt : A salt which contains O^{2-} or OH^- group in its molecule is called basic salt.

Examples : The compounds like Mg(OH)Cl, $[Mg(OH)_2 \cdot MgCO_3]$, $[Cu(OH)_2 \cdot CuCO_3]$ etc are basic salts.

(iv) Acidic Salt : A normal salt which is formed by the neutralisation of a strong acid and a weak base is called acidic salt because its aqueous solution turns blue litmus red.

Examples : The compounds like $FeCl_3$, $ZnCl_2$, $HgCl_2$, $Fe_2(SO_4)_3$, $HgSO_4$ etc are acidic salts.

(v) Alkaline Salt : Normal salts which are formed by the neutralisation of a weak acid and strong base are called alkaline salts because their aqueous solutions turn red litmus blue.

Examples : The compounds like Na_2CO_3, CH_3COONa, $Na_2C_2O_4$, $Na_2B_4O_7$, 10 H_2O etc are alkaline salts.

(vi) Neutral Salt : Normal salts are those which are formed by the neutralisation of a strong acid and a strong base are called neutral salts because their aqueous solutions are neutral to the litmus.

Examples : The compounds like NaCl, KCl, K_2SO_4, $NaNO_3$, $KClO_3$, $KClO_4$ etc. are neutral salts.

(vii) Double Salt : A double salt is a mixture of two salts which on dissolution in water gives two types of metal ions.

Examples : The compounds like Potash Alum [$K_2SO_4 \cdot Al_2(SO_4)_3 \cdot 24\ H_2O$], Mohr's salt [$FeSO_4 \cdot (NH_4)_2SO_4 \cdot 6H_2O$], Ferric Alum [$K_2SO_4 \cdot Fe_2(SO_4)_3 \cdot 24\ H_2O$] etc are double salts.

(viii) Complex Salt : A complex salt is a salt which contains a complex ion or complex neutral molecule in which there is a central metal ion surrounded by a number of neutral molecules or negative ions.

Examples : The compounds like potassium ferrocyanide ($K_4[Fe(CN)_6]$), potassium argento cyanide ($K[Ag(CN)_2]$), tetra amino cupric sulphate ($[Cu(NH_3)_4]SO_4$) etc. are complex salts.

Uses of Salts :

(i) Uses of Sodium chloride (NaCl) : This is an ordinary salt and used frequently in human food stuffs, as a preserver of dress chicken, mutton and fish, in the manufacturing of various chemical compounds etc.

(ii) Uses of Sodium bicarbonate ($NaHCO_3$) : This is used as a baking powder in the kitchens, in removing acidity from human body, in fire extinguisher devices etc.

(iii) Uses of Sodium carbonate ($Na_2CO_3.10\ H_2O$) : This is used as caustic soda, in the dry cleaning of clothes, in the manufacturing of glasses, in the manufacturing of detergents, in the manufacturing of various chemical compounds etc.

(iv) Uses of Potassium nitrate (KNO_3) : In the production of gun powder, in the manufacturing of core components of the fire crackers, in glass industry, in the production of fertilizers etc.

(v) Uses of Copper sulphate ($CuSO_4.5H_2O$) : This is used frequently as insecticides, in electroplating, in the colouration and printing, in the purification of copper etc.

(vi) Uses of potash alum [$K_2SO_4 \cdot Al_2(SO_4)_3.24H_2O$] : This is frequently used in the purification of water, in the manufacturing of drugs, as a colour bonding in colouration, in the leather industries etc.

Hydrolysis of Salts : When salts of strong acids and strong bases are dissolved in water, they simply ionize in the solution but do not react with water.

Although, when a salt of strong base and weak acid or weak base and strong acid is dissolved in water, it reacts with water to produce the original acid and base from which the salt was formed. This process is called hydrolysis of salts.

pH value : The pH value of a substance is a number which simply represents the acidity and basicity of the substance. The pH value of solution is numerically equal to the logarithm of the inverse of the hydrogen ion (H^+) concentration.

Thus; $pH = \log\left[\frac{1}{H}\right] = -\log[H^+]$

The *pH* value of a substance lies between 0 to 14. If the solution of the substance has its *pH* value less than 7 then the substance is acidic but if its *pH* value is more than 7 then the substance is alkaline (basic) while if *pH* value is exactly 7 then the substance is neutral. Thus various substances like alcohol, sugar, pulp-paper etc have various *pH* values which are frequently used in industries.

***pH* values of some ordinarily used substances :**

Substances	*pH* values	Substances	pH values
Lemon	2.2 – 2.4	Vingear	2.4 – 3.4
Wine	2.8 – 3.8	Tomato juice	4.0 – 4.4
Bear	4 – 5	Coffee	4.5 – 5.5
Human urine	5.5 –7.5	Pure water	7
Human blood	7.3 – 7.5	Milk	6.4 – 6.6

Buffer Solution : The solution which resists changing in *pH* value without disturbing the original acidity and alkalinity (basicity) of the solution is called buffer solution. The solution of sodium acetate and acetic acid is an example of a buffer solution. The solution in which buffer solution is accommodated that works like an extremely weak acid.

8. Chemical Symbol, Formula and Equation

Chemical Symbol : The complete name of an element is expressed in short by a letter or a group of letters, this is called chemical symbol. In chemistry the chemical symbols of the elements were developed and propounded by Berzelius in 1811.

Generally the first letter of the corresponding element of English, French, or German name is a chemical symbol.

Some elements and their symbols :

Elements	Symbols	Elements	Symbols
Hydrogen	H	Barium	Ba
Nitrogen	N	Calcium	Ca
Bromine	Br	Fluorine	F
Manganese	Mn	Carbon	C
Magnesium	Mg	Oxygen	O
Chlorine	Cl	Phosphorus	P
Bismuth	Bi	Molybdenum	Mo

Some elements whose symbols are based upon their Latin name :

Common Name of the elements	Latin Name of the corresponding elements	Symbols
Sodium	Natrium	Na
Copper	Cuprum	Cu
Potassium	Kalium	K
Silver	Argentum	Ag
Iron	Ferrum	Fe
Gold	Aurum	Au

Chemical formula : The group of symbols through which the molecule of an element or a compound is expressed in short is called chemical formula.

Normally chemical formulae are of three types :

(i) Molecular formula : The formula through which the actual number of atoms present in the element or compound are exhibited is called molecular formula.

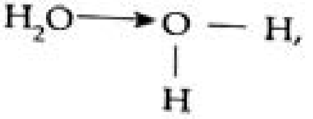
Examples : The element hydrogen has two atoms in its molecule, so its molecular formula is H_2. Similarly in a molecule of water there are two hydrogen atoms and one oxygen atom, so its molecular formula is H_2O.

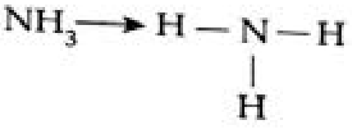
(ii) Emperical formula : The formula through which the simplest ratio of the number of atoms present in the compound are exhibited is called emperical formula.

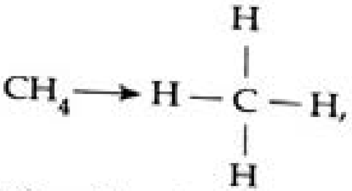
Examples : The organic compound ethane (C_2H_6) has its emperical formula CH_3, while acetelyne (C_2H_2) and benzene (C_6H_6) have same emperical formula CH.

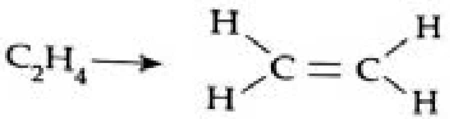
(iii) Structural formula : The formula through which the arrangement of the atoms of the element in the compound are exhibited is called structural formula.

Examples :









Relationship between emperical and molecular formula : The molecular formula of a chemical substance is the simple multiplier of its emperical formula.

Thus; n = Molecular formula / Emperical formula
where $n = 1, 2, 3$ ....

Chemical Equation : Chemical equation is a short representation of the elements or chemical compounds which take part in the real chemical reaction by the help of chemical symbols and molecular formulae.

Thus; the burning of carbon in oxygen and to form carbondioxide can be expressed by a chemical equation given as below;

$$C + O_2 \longrightarrow CO_2.$$

Thermochemical Equation : The chemical equation in which change in heat energy is expressed alongwith corresponding chemical reactions is called thermochemical equation. In the chemical reaction the released free energy is represented by + sign, while absorbed energy is represented by – sign. Also the chemical reaction in which free energy released is called exothermic reaction, while energy absorbed in the reaction is called endothermic reaction. The formation of ammonia (NH_3) by the chemical reaction of nitrogen (N_2) and hydrogen (H_2) is an exothermic reaction.

$$N_2 + 3H_2 \longrightarrow 2NH_3 + 22.5 \text{ k cal.}$$

The formation of nitric oxide (NO) by the chemical reaction of nitrogen (N_2) and oxygen (O_2) is an endothermic reaction.

$$N_2 + O_2 \rightleftharpoons 2NO - 43.6 \text{ kcal.}$$

Ionic Equation : The chemical reaction in which actual atoms and ions are exhibited in the real form of an equation is called ionic equation.

Example : The ionic equation between zinc (Zn) and dil. sulphuric acid (dil. H_2SO_4) can be displayed as below ;

$$Zn + 2H^+ \longrightarrow Zn^{2+} + H_2.$$

Similarly ; $Zn + Cu^{2+} \longrightarrow Zn^{2+} + Cu.$

9. Chemical reactions

The process in which the atoms of the substance or substances are rearranged in such a way that the result of which another substance or substances are formed is called chemical reaction and it is expressed by the chemical equation. In other words, we can say that if one substance reacts with another substance or any substance reacts itself and form a new substance or substances then this activity is called chemical reaction.

Example : If the mixture of hydrogen and oxygen is burnt out then the water is formed.

$$2H_2 + O_2 \longrightarrow 2H_2O.$$

Thus the chemical reaction is a process of splitting of bonds and the formation of some other bonds among the atoms. Therefore a large amount of energy of various forms like heat energy, light energy, mechanical energy etc are produced in the chemical reactions.

Examples of the chemical reactions in our daily life : There are various examples of chemical reactions in our daily life like the oxidation of the food-stuffs inside the human body, the respiration or breathing mechanism, the ripening process of fruits, to prepare wine by the process of fermentation of the fruits etc.

Various types of chemical reactions :

(i) Combination reaction : The chemical reaction in which two or more than two substances form a new substance (product) and the characteristics of the new substance are quitely different from the original substances (reactants). Also such reactions occur either among the elements or compounds.

Example : When magnesium is burnt in oxygen gas then the white powder of the magnesium oxide (MgO) is formed.

$$2Mg + O_2 \longrightarrow 2MgO.$$

(ii) Decomposition reaction : The chemical reaction in which a large chemical compound splits or decomposes into two or more smaller chemical compounds. The characteristics of the newly formed compounds (products) are quitely different from the original compound (reactant). Thus the decomposition reaction is the inverse of the combination reaction.

Example : When calcium carbonate ($CaCO_3$) is heated then calcium oxide (CaO) and carbondioxide (CO_2) are produced.

$$CaCO_3 \longrightarrow CaO + CO_2 . \uparrow$$

(iii) Displacement reaction : The chemical reaction in which the atom of an element replaces the atom of another element from the compound and forms a new compound and usually a more active element replaces another which is less active in the compound.

Example : When the pieces of zinc are mixed in the solution of copper sulphate ($CuSO_4$), zinc replaces copper and zinc sulphate ($ZnSO_4$) is formed and alongwith it copper is precipitated.

$$Zn + CuSO_4 \longrightarrow ZnSO_4 + Cu. \downarrow$$

(iv) Double decomposition reaction : The chemical reaction in which two substances (reactants) do mutual transfer of their respective groups and form two new chemical compounds.

Example : When sodium sulphate (Na_2SO_4) reacts with barium chloride ($BaCl_2$) then the white precipitate of barium sulphate ($BaSO_4$) and sodium chloride (NaCl) are obtained.

$$Na_2SO_4 + BaCl_2 \longrightarrow BaSO_4 \downarrow + 2NaCl.$$

(v) Precipitation reaction : The chemical reaction in which two substances (reactants) do mutual transfer of their respective groups and form an insoluble precipitated chemical compound.

Example : When silver nitrate ($AgNO_3$) reacts with sodium chloride (NaCl) then a white precipitate of silver chloride (AgCl) like curd and sodium nitrate ($NaNO_3$) are obtained.

$$AgNO_3 + NaCl \longrightarrow AgCl \downarrow + NaNO_3.$$

(vi) Neutralisation reaction : The chemical reaction in which acid and base do mutual transfer of respective groups (radicals) and form salt and water.

Example : When the aqueous solution of sodium hydroxide (NaOH) reacts with the aqueous solution of hydrochloric acid (HCl) then sodium chloride (NaCl) and water (H_2O) are obtained.

$$NaOH + HCl \longrightarrow NaCl + H_2O.$$

(vii) Hydrolysis reaction : The chemical reaction in which the salt of weak acid or weak base comes in the contact of water and it reacts with acid or base in the partial form.

Example : By the hydrolysis of sodium carbonate (Na_2CO_3), sodium hydroxide (NaOH) and carbonic acid (H_2CO_3) are formed.

$$Na_2CO_3 + 2H_2O \longrightarrow 2NaOH + H_2CO_3.$$

(viii) Isomerisation reaction (Rearrangement reaction) : The chemical reaction in which the atoms of the molecule of a compound is accommodated (arranged) in such a way that molecular formula of the original (old) and new compound are same. Thus the conversion of an isomerised compound into another isomerised compound is called isomerisation. The phenomenon of isomerisation is found mostly in organic compounds.

Example : The isomerisation of ammonium cyanate (NH_4CNO) into urea (NH_2CONH_2).

$$NH_4CNO \longrightarrow NH_2CONH_2.$$

(ix) Endothermic reaction : The chemical reaction in which heat is absorbed is called an endothermic reaction.

Example : To form nitric oxide (NO) by the combination of nitrogen and oxygen.

$$N_2 + O_2 \longrightarrow 2NO - 43.2 \text{ kcal}.$$

(x) Exothermic reaction : The chemical reaction in which heat is released is called an exothermic reaction.

Example : To form water (H_2O) by the combination of hydrogen and oxygen.

$$2H_2 + O_2 \longrightarrow 2H_2O + 136.74 \text{ kcal}.$$

(xi) Reversible reaction : The chemical reaction which proceeds in both directions is called reversible reaction.

Example : When the water vapour is supplied on the red heated iron, then ferso-feric oxide (Fe_3O_4) and hydrogen are formed.

Example : $3Fe + 4H_2O \rightleftharpoons Fe_3O_4 + 4H_2$

(xii) Irreversible reaction : The chemical reaction which proceeds in only one direction is called irreversible reaction.

Example : $2KClO_3 \longrightarrow 2KCl + 3O_2$;

$NaOH + HCl \longrightarrow NaCl + H_2O.$

10. Change in energy in chemical reactions

The chemical reactions occur due to the difference in energy of reactants and products. In fact the reactants have more energy and take part in the chemical reaction to achieve a more stable state (lowest energy). Thus usually in a chemical reaction the energy of the reactants is more than the energy of the products.

Activated state and Activation energy : Before involving in a chemical reaction the reactants absorb some extraneous energy from anywhere and transformed themselves in a higher energy state, this is called activated state or excited state. The extraneous energy by which the reactants go to a higher energy state is called activation energy.

On the basis of activation energy and the change of energy between the reactants and products, the chemical reactions are of two types—

(i) Exothermic reaction : The chemical reaction in which heat is released is called an exothermic reaction.

Examples : $N_2 + 3H_2 \longrightarrow 2NH_3 + \Delta E$ (Heat)

$C + O_2 \longrightarrow CO_2 + \Delta E$ (Heat)

(ii) Endothermic reaction : The chemical reaction in which heat is absorbed is called an endothermic reaction.

Examples : $N_2 + O_2 \xrightarrow{3000^\circ} 2NO - \Delta E$ (Heat)

$C + 2S \longrightarrow CS_2 - \Delta E$ (Heat)

Bonding energy : The energy needed to break all the bonds of the molecules of a substance of one mole and to transform all the molecules into the atoms is called bonding energy. In other words the mutual combination of free atoms require some energy to form the bonds of the molecules in one mole substance is called bonding energy. The bonding energy of the substance is expressed in kilo Joule per mole.

Thus the breaking of the bonds of the substance is an exothermic reaction, while the formation of the bonds is an endothermic reaction.

Heat of reaction : The energy released or absorbed after completing a chemical reaction is called heat of reaction.

Example : $2H_2 + O_2 \longrightarrow 2H_2O + 483$ k Joule.

Heat of formation : The energy released or absorbed in the formation of 1 mole of a compound by their constituent components of the elements is called heat of formation.

Examples : $H_2 + 1/2\, O_2 \longrightarrow H_2O + 241.5$ k Joule.

Heat of combustion : The thermal energy obtained by burning a molecule of the substance in the oxygen gas is called heat of combustion.

Example : $C + O_2 \longrightarrow CO_2 + 395$ k Joule.

Photo chemistry and photo chemical reaction : The branch of chemistry in which those chemical reactions are studied which are happened in the presence of sunlight is called photo chemistry.

The chemical reaction which activates by absorbing the sunlight is called a photo chemical reaction.

Examples : $H_2 + Cl_2 \xrightarrow{\text{sunlight}} 2HCl$

$Cl_2 \xrightarrow{\text{sunlight}} 2Cl$

(chlorine molecule) (chlorine atom)

$6CO_2 + 12H_2O \xrightarrow{\text{sunlight}} C_6H_{12}O_6 + 6H_2O + 6O_2$.

The last chemical reaction is a photo chemical reaction because it occurs in the presence of sunlight in the green plants which is called photosynthesis. Obviously in the photosynthesis light energy is transformed into chemical energy.

Metallic corrosion : The metallic corrosion is an oxidation-reduction process in which metals absorb the atmospheric air and moisture and react during which some unwanted substances are formed in the form of layers on the metals. In fact the metals in the presence of air and moisture get oxidised and convert themselves into the mixture of oxide and hydroxide and the process is continued until the metals is not to be completely destroyed.

Examples : (i) When an iron piece is left for a longer time in the moist air then a layer of brown colour around it is appeared.

(ii) When a copper piece is left for a longer time in moist air then a layer of faint green colour around it is appeared.

There are certain metals like platinum, gold, silver etc in which the process of metallic corrosion does not occur and such metals are called novel metals.

Rusting of iron : The rusting of iron is an oxidation reaction and it is one of the best example of the metallic corrosion. In the presence of air and moisture the phenomenon of metallic corrosion takes place and consequently the mixture of ferric oxide (Fe_2O_3) and ferric hydroxide [$Fe(OH)_3$] appears as loosened layers in brown colour which is called rusting of iron.

$$4Fe + 3O_2 + 3H_2O \longrightarrow FeO_3 + 2HFe(OH)_3.$$

Galvanization : To avoid the rusting and for a longer life of the metallic bodies like of copper, iron etc. a thin layer of zinc is coated on such bodies which is called galvanization and metallic bodies are said to be galvanized.

Thus by any way or means if the contact of air and moisture is removed from the metallic bodies then the process of metallic corrosion can not be occured and the rusting is stopped. Exactly this process is followed in the galvanization.

11. Solution

The homogeneous mixture of two or more substances in which at a constant temperature the relative amounts of the solute and solvent can change up to a definite limit is called solution.

The solution of salt in water, the solution of sugar in water etc. are the examples of the solution.

Characteristics :

(i) The solution is a homogeneous mixture of two or more substances and in the solution the radius of the solute particles is less than 10^{-7} cm, that's why these particles can not be seen even through the microscope.

(ii) In the solution the solute and solvent particles diffuse to each other in such a way that they can not be distinguished.

(iii) The solute particles present in the solution can not be filtered through the bloting paper.

(iv) The solution is permanent and transparent.

Solute and Solvent : In a solution the substance presents in smaller amount is called solute, while the substance presents in larger amount is called solvent. The solvent which has larger dielectric constant is a better solvent. The value of the dielectric constant for the water is large, so it is called Universal solvent.

Uses of solvents :

(i) In the manufacturing of drugs.

(ii) In the dry cleaning where solvents like benzene, petrol etc. are used.

(iii) In the manufacturing of perfumes, in colouration etc.

(iv) In the processing of various types of food stuffs and in the production of various types of beverage.

Classification of solutions :

Types of solution	**Examples**
Solution of gas in gas	Air, mixture of gases.
Solution of liquid in gas	Solution of gases like Br, CO_2, NH_3 etc in water, cloud, mist, fog etc.
Solution of solid in gas	Solution of iodine in air, smoke etc.
Solution of gas in liquid	Solution of CO_2 in water (H_2O), solution of HCl gas in benzene (C_6H_6) etc.
Solution of liquid in liquid	Solution of alcohol in water, solution of bromine in carbon disulphide, solution of H_2SO_4 in water etc.
Solution of solid in liquid	Solution of sugar in water, solution of iodine in carbon tetrachloride, solution of lead in mercury, starch, gel, protein etc.
Solution of gas in solid	Solution of hydrogen in Palledium metal, solution of camphor in air etc.
Solution of liquid in solid	Solution of mercury in thalium, solution of water in sugar, solution of water in salt etc.
Solution of solid in solid	Zinc in copper, tin in copper, aluminium in copper, solution (alloys) of zinc and nickel in copper.

Saturated, Unsaturated and Super saturated solution : The solution in which the maximum amount of the solute is dissolved at a fixed temperature is called saturated solution.

The solution in which some more amount of the solute can be dissolved at a fixed temperature is called unsaturated solution.

But if the temperature of saturated solution is increased then the capacity of the solute to dissolve in the solution is also increased and it is called supersaturated solution. Thus in super saturated solution an excess amount of the solute is dissolved in the solution which is beyond the capacity of the solution at a fixed temperature.

Solubility : The maximum amount of solute dissolved in 100 gm solvent at a definite (fixed) temperature and pressure is called the solubility of the solute in that solvent.

Thus if at any temperature say t°C, w gm solute be dissolved in W gm of solvent, say water then the solubility of the solute in the water

$$= \frac{w \times 100}{\cdots}$$

Effect of temperature on solubility : Ordinarily the solubility of the solid substances increase with increase of temperature. But there are certain solid substances like sodium sulphate, calcium hydroxide, calcium cytrate etc whose solubility decreases with increase of temperature.

The solubility of gas in the liquid decreases with rise of temperature.

Some important facts related to solubility :

1. Non-polar substance dissolves in non-polar solvents. Example; bromine is soluble in carbon tetra chloride.
2. Non-polar substance is not more soluble in polar solvents. Example; carbon tetra chloride is not more soluble in water.
3. Usually polar substance dissolves in polar solvents. Example; Ethyl alcohol is more soluble in water.
4. Polar substance doesn't dissolve more in non-polar solvents. Example; Sodium chloride is not more soluble in carbon tetrachloride.
5. As the molecular weight of the substances increase their solubilities decrease. Example ; Butyl alcohol (molecular wt. = 74) is less soluble than methyl alcohol (molecular wt. = 32) in water.

Concentration of solution : The amount of solute present in unit amount of the solvent or solution is called concentration of the solution. Also if a little amount of solute be dissolved in the solution then the solution is said to be dilute and this is unsaturated solution.

Micro-level classification of solution :

Dispersion : If the constituent particles (molecule, atom or ion) of a substance is scattered around the another substance then it is called dispersion.

Here the first substance is called dispersed substance and second substance is called dispersive medium or medium of dispersion. During the phenomenon of dispersion two types of substances are formed —

(i) Heterogeneous substances like suspension, colloid etc.

(ii) Homogeneous substances like true solution.

The sizes of the dispersed particles in suspension, colloid and true solution are different.

Suspension : The substance of a little size particles which are insoluble in solvent, but which are visible distinctly through the naked eye is called suspension.

Thus it is a heterogeneous mixture of two or more substances and in it the sizes of the dispersed particles are of the order of 10^{-5} cm or more. The little particles can be filtered and these are temporary which have a common tendency to scatter from the medium of dispersion. There are so many examples of suspension in our common walk of life like polluted water of river, smoke in atmospheric air etc.

Colloid or colloidal solution : This is a heterogeneous mixture of two substances in which the order of the sizes of the dispersed particles lie between 10^{-5} cm to 10^{-7} cm. These dispersed particles can not be seen through the naked eye but can be distinctly seen through ultra microsc and can not be filtered by the blotting paper. These dispersed particles of the colloidal solution are permanent and have a lesser tendency to scatt from the medium of dispersion.

There are so many examples of colloidal solution like milk, gem, blo ink etc.

True solution : This is a homogeneous mixture of two or more substance and the dispersed particles has the molecular order of the range of the 10^{-8} cm. In true solution the dispersed particles diffuse or intermix in the medium of dispersion in such a way that both can not be distinguished. The dispersed particles can easily cross the blotting paper and cannot be filtered. The true solution is the most permanent and transparent among all types of solutions.

The examples of true solution are the solution of sugar in water, the solution of ordinary salt in water etc.

Neutral, Acidic and Alkaline solution : The solution in which the concentration of hydrogen ions (H^+) and hydroxide ions (OH^-) is equal then it is called a neutral solution.

But the solution in which the concentration of hydrogen ions (H^+) is more than that of hydroxide ions (OH^-) then it is called an acidic solution while the solution in which the concentration of hydroxide ions (OH^-) is more than that of hydrogen ions (H^+) then it is called an alkaline solution.

12. Gases law

Boyle's law : The volume of a definite amount of a gas at a constant temperature is inversely proportional to the pressure of the gas.

If at a constant temperature the volume of a definite amount (mass) of a gas is V and its corresponding pressure be p then

$$V \alpha \frac{1}{p} \text{ or, } V = K\frac{1}{p}$$

where K is a proportionality constant.

$$\Rightarrow \quad pV = K \text{ (constant)} \qquad \Rightarrow \quad p_1V_1 = p_2V_2$$

Thus at a constant temperature the product of the pressure and volume remains constant.

$$\text{But, since;} \quad \text{volume} = \frac{\text{mass}}{\text{density}}$$

$$\Rightarrow \quad V = \frac{m}{d} . \Rightarrow V_1 = \frac{m}{d_1} \text{ and } V_2 = \frac{m}{d_2}$$

Thus, by Boyle's law

$$p_1 \cdot \frac{m}{d_1} = p_2 \cdot \frac{m}{d_2} \Rightarrow \frac{p_1}{d_1} = \frac{p_2}{d_2} \Rightarrow \frac{p}{d} = \text{constant.}$$

$\Rightarrow$ $p \propto d$. This tells that the pressure of the gas is directly proportional to its density at a constant temperature.

Charle's law : The volume of a definite amount of a gas at a constant pressure is directly proportional to the absolute temperature.

If at a constant pressure the volume of a definite amount (mass) of the gas is V and its corresponding temperature (absolute) is T then

$V \propto T$ or, $\frac{V}{T} = K$ where; K is proportionality constant.

$$\Rightarrow \frac{V_1}{T_1} = \frac{V_2}{T_2}$$

Pressure's law : The pressure of a definite amount of a gas at a constant volume is directly proportional to the absolute temperature.

If at a constant volume the pressure of a definite amount (mass) of a gas is p and its corresponding temperature (absolute) is T then

$p \propto T$ or, $\frac{p}{T} = K$, where K is a proportionality constant.

$$\Rightarrow \frac{p_1}{T_1} = \frac{p_2}{T_2} \Rightarrow p_1T_2 = p_2T_1$$

Gaseous equation of state : The equation of state of a substance of a definite amount is an equation in which pressure, temperature and volume are involved.

For 1 mole gas, by Boyle's law $p \propto \frac{1}{V}$, where T is a constant.

Now, by charles law ;

$p \propto T$, where V is a constant.

Now, combining both Boyle's and Charle's law ;

$p \propto \frac{T}{V}$, when both T and V vary

$\Rightarrow p = R\frac{T}{V}$; where R is a constant called universal gas constant.

$$\Rightarrow R = \frac{pV}{T} \text{ i.e. } \frac{p_2V_2}{T_1} = \frac{p_2V_2}{T_2} \Rightarrow pV = RT$$

This is the required gaseous equation of state.

Similarly; for n mole gas $pV = nRT$.

Absolute temperature scale : The temperature scale in which – 273°C is assumed to be zero is called absolute temperature scale. Also the absolute zero is a temperature at which molecular motion cease.

Thus 0°C = 273 K, 100°C = 273 + 100 = 373 K.

$\Rightarrow$ T K = (T–273)°C.

Standard temperature and pressure (*STP*) or Normal temperature and pressure (NTP) : The temperature 0°C or 273 K is called normal temperature or standard temperature. When in a barometer the mercury column is 760 mm then this atmospheric pressure is called normal pressure or standard pressure. This is equivalent to 1 atmospheric pressure. Thus 0°C temperature and 760 mm (76 cm) of Hg (mercury) is called *STP* or *NTP*.

Diffusion of gases : Natural process of intermixing of different gases having difference in their densities and existence of their own forces of gravity is called diffusion.

In unit time the volume of a gas diffused from a hole of a gaseous container is called rate of diffusion or velocity of the diffusion of the gas.

Graham's law of diffusion: Graham in 1883 propounded a comprehensive theory regarding the rate of diffusion of gases and it is called Graham's law of diffusion stated as below ;

At a constant temperature and pressure the rate of diffusion of various gases are inversely proportional to the square root of the densities of the gases.

Thus if two gases have relative densities d_1 and d_2 and their respective rates of diffusion be r_1 and r_2 then

$$r_1 \propto \frac{1}{\sqrt{d_1}}, r_2 \propto \frac{1}{\sqrt{d_2}}$$

$$\Rightarrow \quad r_1 = \frac{k}{\sqrt{d_1}}, r_2 = \frac{k}{\sqrt{d_2}}$$

$$\Rightarrow \quad \frac{r_1}{r_2} = \sqrt{\frac{d_2}{d_1}} \qquad \Rightarrow \text{rate of diffusion} \propto \frac{1}{\sqrt{\text{density}}}$$

Thus, the lighter gases diffuse at a faster rate and vice-versa.

Applications: The phenomenon of the gaseous diffusion are used at various occasions like in the production of Ansal's marsh gas, in the separation of the gaseous mixtures, in the determination of vapour densities of the gases, in the separation of the isotopes etc.

Dalton's law of partial pressure : It states that the total pressure of a gaseous mixture of a definite volume of the gas is equal to the sum of partial pressure of the component gases.

If there are three gases *A*, *B* and *C* whose partial pressures are p_A, p_B and p_C then according to Dalton's law of partial pressure total pressure (p) of the gas = $p_A + p_B + p_C$.

Avogadro's hypothesis : At equal temperature and pressure in equal volumes of all gases there are equal number of molecules.

If at equal temperature and pressure a gas has volume *V* and there is *n* mole gas then

$V \propto n$ i.e. volume of the gas is directly proportional to the no. of mole.

13. Chemical kinetics & Chemical equilibrium

Chemical kinetics : The branch of chemistry under which the rate of chemical reactions and the activities related to its inner mechanisms are studied is are called chemical kinetics.

On the basis of the rate of reaction, chemical reactions can be classified into two categories —

A. Fast reaction : The chemical reaction which ends quickly, because of the very fast rate of reaction and such reaction can not be allocated (determined).

Generally, ionic chemical reactions occur in such way. For example, if the solution of sodium chloride ($NaCl$) is mixed up in the solution of silver nitrate ($AgNO_3$) then the chemical reaction occurs so rapidly and quickly that it is impossible to determine the rate of reaction.

B. Slow reaction : The chemical reaction which proceeds very slowly and whose rate of reaction can be evaluated at an ordinary temperature and the action process of the reaction can be studied easily. For example, the reaction between ethyl alcohol (C_2H_5OH) and accetic acid (CH_3COOH) in the presence of H_2SO_4 is an example of slow reaction.

$$CH_3COOH + C_2H_5OH \rightleftharpoons CH_3COOC_2H_5 + H_2O$$

Homogeneous and Heterogeneous reactions : The chemical reactions in which reactants are to be found in the same physical state then the chemical reactions are called homogeneous reactions. But if the reactants of the chemical reactions are to be found in more than one physical states then the chemical reactions are called heterogeneous.

Generally under the chemical kinetics heterogeneous types of chemical reactions are studied.

Rate of reaction : The change of concentration of the reactants or products in a chemical reaction in unit time is called the rate of reaction. Since during the occurrence of a chemical reaction the concentration of the reactants decrease and the concentration of the products increase. Thus, the rate of reaction can also be defined as the rate of decrease of the concentration of the reactants or the rate of increase of the concentration of the products.

Factors governing the rate of reactions : There are various factors (parameters) which govern the rate of chemical reactions and these are following;

1. Concentration of the reactants : The rate of reaction is directly proportional to the concentration of the reactants. Thus larger the concentration of the reactants, faster would be the rate of reaction and vice-versa.

2. Temperature : Generally at higher temperature of the reactants the rate of reaction is fast and vice-versa.

3. Physical state of reactants : The physical state of reactants specially affects the chemical reactions of the heterogeneous type in which reactions occur on the outer surface (layer) of the reactants. Generally the larger area of its outer surface activates the chemical reactions to occur rapidly. If a solid reactant is broken into a number of pieces then its surface area is increased and the rate of reaction automatically becomes faster.

4. Nature of reactants : The rate of chemical reaction is directly and sharply affected by the nature of reactants. For example; sodium metal reacts rapidly with water at an ordinary temperature.

5. Effect of catalyst : In the presence of catalyst the rate of reaction may either increase or decrease. In fact in the presence of catalyst the activation energy and the processing of action of the chemical reaction changes. The positive catalyst decreases the activation energy and the rate of reaction becomes fast, while the negative catalyst increases the activation energy and so the rate of reaction becomes slow down.

6. Effect of radiation : The rate of chemical reaction is also affected by the radiation. For example ; hydrogen and chlorine reacts extremely slowly in dark, while reacts very rapidly in the presence of sunlight.

Thus ; $H_2 + Cl_2 \xrightarrow{\text{dark}} 2HCl$ (extremely slow)

$H_2 + Cl_2 \xrightarrow{\text{sunlight}} 2HCl$ (extremely fast)

Molecularity of the reaction : The minimum number of atoms or molecules of the reactants which take part in a chemical reaction is called molecularity of the reaction.

Examples : $CH_3COOC_2H_5 + NaOH \longrightarrow CH_3COONa + C_2H_5OH$.

molecularity of the reaction = 1 + 1 = 2

$H_2O_2 \longrightarrow H_2O + \frac{1}{2}O_2$. molecularity of the reaction = 1

Order of the reaction : The sum of the powers (exponent of indices) of the terms associated with the concentration in the chemical reaction is called order of the reaction.

Reversible and Irreversible reactions : The chemical reactions which proceed in both directions either from left to right or from right to left are called reversible reactions. The reactions which proceed from left to right are called forward reactions, while the reactions which proceed from right to left are called backward reactions or reverse reactions. In reversible reactions the reactants transform themselves into the products and vice-versa.

Examples : $3Fe + 4H_2O \rightleftharpoons Fe_3O_4 + 4H_2$.

$N_2 + 3H_2 \rightleftharpoons 2NH_3$.

The chemical reactions which proceed in only one direction from left to right are called irreversible reactions.

Examples : $2KClO_3 \longrightarrow 2KCl + 3O_2$.

$NaOH + HCl \longrightarrow NaCl + H_2O$.

Chemical equilibrium : The state of a chemical reaction in which the rate of forward reaction is equal to the rate of backward reaction is called chemical equilibrium. As the chemical equilibrium is dynamic (executing motion) so sometimes chemical equilibrium is also called dynamic equilibrium.

Classification of chemical equilibrium :

Generally there are two types of chemical equilibria—

(i) Homogeneous equilibria : A chemical reaction which is in an equilibrium and in which the reactants and the products are to be found in the same physical state (solid, liquid or gas).

(ii) Heterogeneous equilibria : A chemical reaction which is in an equilibrium and in which the reactants and the products are to be found in different physical states.

Equilibrium Constant : The ratio of the rate of forward reaction to the rate of backward reaction is called equilibrium constant. The value of this constant is being constant at a fixed temperature but its value changes with change of temperature.

Law of mass action : Norway based two chemists Gulberge & Wage in [illegible] propounded a comprehensive theory regarding the rate of chemical reactions and its effect by the mass of the substances involved in it which is known as law of mass action and it is stated as below ;

The rate of chemical reaction of a substance is directly proportional to the active mass of the substance. In other words the rate of chemical reaction of the reactants is directly proportional to the product of active masses of the reactants.

14. Electro Chemistry

The branch of chemistry under which those chemical reactions are studied which occur during passing the electric current is called electro chemistry.

Electrolytes and Non-electrolytes : Electrolytes are those substances (compounds) which are found in the liquified state but whose aqueous solutions are good conductor of electricity. Examples ; Acid, base or alkali, salt etc are electrolytes.

While non-electrolytes are those substances (compounds) which are found in the liquified state but whose aqueous solutions are bad conductor of electricity. Examples; sugar, urea, chloroform etc.

Electrolysis : The process of decomposition (dissociation) of the liquified state of the substance (compound) or its aqueous solution by passing an electric current is called electrolysis.

Electrolytic cell : Electrolytic cell has a container in which an electrolyte is kept inside it and the phenomenon of electrolysis is completed under the suitable conditions. In an electrolytic cell two metallic plates or metallic wires are inserted in the container called electrodes. The electrodes of the cell are attached through the positive and negative terminals of the battery. The electrode which is attached with the positive terminal of the battery is called cathode and attached with the negative terminal of the battery is called anode. The electrolyte in the solution decomposes into charged radicals or groups which are called ions. The positively charged ions are called cations, while the negatively charged ions are called anions. On passing an electric current through the electrolyte cations are formed on the cathode and anions on the anode. Also an oxidation takes place on the anode and a reduction takes place on the cathode during the electrolysis.

Faraday's law of electrolysis : On the basis of various experiments conducted by Michale Faraday regarding the phenomenon of electrolysis he propounded two laws which are called Faraday's laws of electrolysis stated as below;

First law : The quantity of the substance released from each electrode during the electrolysis is directly proportional to the quantity of electric current passed through the electrolyte.

If through an electrolyte I ampere electric current is passing in t second and due to it if m gm substance is deposited then;

$$m \propto I.t \Rightarrow m = ZIt.$$

where; Z is a constant called electro chemical equivalent.

Here, if $I = 1$ amp.

$t = 1$ sec.

then $m = Z$

This tells us that the electro chemical equivalent of a substance is the mass required which is obtained from the substance (electrolyte) on passing 1 amp current up to 1 sec.

Second law : If an electric current is passed through various electrolytes grouped in series then the amount of the substances deposited are directly proportional to their respective chemical equivalents.

If x, y, z .... are the deposited amounts of the substance and E_1, E_2, E_1 .... are their respective chemical equivalents then

$$\frac{x}{E_1} = \frac{y}{E_2} \text{ and } \frac{x}{E_1} = \frac{z}{E_3}$$

Also, from first law,

$$x = Z_1 It,\ y = Z_2 It,\ z = Z_3 It$$

where, Z_1, Z_2 and Z_3 are electro chemical equivalents of the deposited substances.

$$\Rightarrow \quad \frac{x}{y} = \frac{Z_1}{Z_2} = \frac{E_1}{E_2} \text{ and } \frac{y}{z} = \frac{Z_2}{Z_3} = \frac{E_2}{E_3} \Rightarrow Z \propto E$$

This concludes that the electro chemical equivalent of a substance is directly proportional to the chemical equivalent of the substance.

Faraday : When an electric current due to 96494 Coulomb charge passes up to 1 sec through an electrolyte then the equivalent weight of the substance deposited is one and this amount of the electric current is called 1 Faraday.

Thus; 1 Faraday = 96494 coulomb (approx. 96500 coulomb)

Application of electrolysis :

1. **In electroplating :** Low quality metal is laminated in the form a thin layer on good quality metal for a longer life and attractive look by the process of electrolysis is called electroplating.
2. **In electrotyping :** The blocks, graphics etc in the printing industries are composed by the process of electrolysis is called electrotyping.
3. **In electro refining of metals :** The metals like copper, silver, gold etc are obtained in their pure forms by the process of electrolysis is called electro refining of metals.
4. **In electro metallurgy :** There are certain metals like sodium, potassium, aluminium, calcium, magnesium etc. which are extracted from their respective compounds by the process of electrolysis is called electro metallurgy.

5. In the evaluation of the equivalent weight of the metals.

6. **In the manufacturing of chemical compounds :** By the process of electrolysis various types of drugs, organic and inorganic compounds are manufactured.

Examples : Caustic soda, hydrogen peroxide, chloroform, iodoform, ethane, acetylene etc are produced by the above process.

Galvanic Cell : Galvanic cell is a system through which chemical energy is transformed into electrical energy. A Daniel cell is a practical and prototype example of a Galvanic cell. In this cell there is a container in which a solution of conc. Copper sulphate ($CuSO_4$) is kept inside it and a copper rod is inserted inside the solution of $CuSO_4$ which acts like a cathode. Inside this container a porous container is kept in which conc. Sulphuric acid (H_2SO_4) is filled up in which a zinc rod is inserted and it acts like an anode. Thus when a wire is connected through a copper rod and a zinc rod an electric current flows.

Electro chemical series : The series obtained by arranging the standard electrode potentials of various elements in a proper way is called electro chemical series. The electrode potential of hydrogen is zero in electro chemical series.

In electro chemical series hydrogen is kept in the middle, while elements like good reducing agents (most active) are kept in the above the elements like good oxidising agents (less active) are kept the below.

Electro chemical series : Li, K, Ba, Sn, Ca, Na, Mg, Al, Zn, Fe, Cd, Co, Ni, Pb, H_2, Cu, Hg, Ag, Pd, Au.

Characteristics :

(i) The larger the value of electrode potential, the tendency to form ions among the metals would be correspondingly more.

(ii) In electro chemical series an element can replace the another element kept at a lower position in the salt solution.

(iii) By the help of this series it can be concluded that an element (metal) can release hydrogen from a hydra acid or not.

(iv) By the electrode potential of the element of this series the possibilities of occurrence of oxidation - reduction reactions can be predicted.

(v) The relative power of oxidising agent and reducing agent can be evaluated by this series.

Arrhenius's theory of electrolytic dissociation or decomposition : To explain the entire aspect of the electrolytic dissociation and the behaviour of an electrolyte in its aqueous solution a Sweden based chemist Arrhenius propounded a theory in 1894 which is called Arrhenius's theory. The main points of this theory were given as below;

(i) The molecules of an electrolyte in aqueous solution split automatically into charged particles which are called ions and the phenomenon is called ionization. The positively charged ions are called cations, while negatively charged ions are called anions.

(ii) In an aqueous solution among ions and ionized molecules a dynamic equilibrium is established.

(iii) In an aqueous solution only certain crystals of all the molecules are ionized and its amount is expressed in the forms of degree of ionization or degree of dissociation.

$$\text{Thus amount of dissociation} = \frac{\text{No. of ionized molecules}}{\text{No. of molecules}}$$

(iv) The phenomenon of the electrolysis occurs on the electrodes only.

(v) The conductivity of the solution depends on the no. of ions present in the solution.

Hydrolysis : The chemical reaction in which ions of the salt and the ions or molecules of the water mutually combine to each other and form an acidic or alkaline solution is called hydrolysis.

Example : When sodium carbonate (Na_2CO_3) hydrolyses in water (H_2O) then sodium hydroxide (NaOH) and carbonic acid (H_2CO_3) are formed.

$$Na_2CO_3 + H_2O \rightleftharpoons 2NaOH + H_2CO_3.$$

***pH* Scale :** The hydrogen ion concentration of an acidic, alkaline, or neutral solution is expressed in the term of *pH*. Thus *pH* value of a solution is defined on a logarithmic scale as negative of the logarithm of the hydrogen ion concentration (H^+) expressed in gm-molecule per litre.

Thus, $pH = -\log_{10}[H^+]$

***pH* value and hydrogen ion concentration [H⁺]**

$[H^+]$	1	10^{-2}	10^{-4}	10^{-6}	10^{-7}	10^{-8}	10^{-10}	10^{-12}	10^{-14}
pH	0	2	4	6	7	8	10	12	14

← Neutral

Increasing Acidity Increasing Alkalinity →

Buffer solution : The solution whose acidity or alkalinity does not alter and remain intact after mixing an the acid or alkali in very small amount and also its *pH* value does not change then it is called a buffer solution.

There are two types of buffer solution —

(i) Acidic buffer : The solution which is a mixture for a weak acid and its salt then it is called an acidic buffer.

Examples : The mixture of a solution of acetic acid and sodium acetate, the mixture of a solution of boric acid and borax etc.

(ii) Basic buffer : The solution which is a mixture of a weak base and its salt then it is called a basic buffer.

Examples : The mixture of a solution of ammonium hydroxide and ammonium chloride etc.

15. Fuels

The substances which provide heat either by alone or by combining and reacting with another are called fuels. Almost all fuels have a substantial amount of carbon within themselves and produces heat on burning these in air. The gaseous fuels are most suitable and preferable than solid and liquid fuels.

The main component of the natural gas is methane (CH_4) and also natural gas is obtained as a bye-product of the petroleum oils which is contined in the wells. The natural gas is basically used in the production of the artificial chemical fertilizers.

Fossils fuels : The fuels which are obtained from the residues of plants, trees, animals (which were remained confine inside the earth since millions of years) are called fossil fuels. Generally in fossil fuels the compounds of carbon having high calorific values are present. The fuels like coal, petroleum, natural gas etc are the examples of fossil fuels.

Main fossil fuels :

1. Coal : The coal is a very important types of the fossils fuel which is found abundantly inside the earth. The coal is mainly made from fully free carbon and its compounds and the compounds of nitrogen, sulphur, iron etc. are also present in small amounts. The coal is mainly classified into four types — Peat, Lignite, Bituminous and Anthracite.

The peat coal is produced in the first phase of the extraction. The coal bituminous is an ordinary type of coal, while anthracite is the best type of coal among all. Nearly all coal of the world is of bituminous type. The Lignite coal is also called brown coal. On burning the anthracite coal no smoke is produced and an extremely large amount of heat is generated. Also the anthracite coal is obtained in the last phase of the coal extraction.

The bituminous coal is mainly used in driving the rail engines and in the preparation of coal gas. In the absence of air if the coal is burnt then coke, coaltar, coal gas etc. are obtained and the process involved is called destructive distillation. Thus customerly coal is used on a large scale as fuels of boiler, engines and furnaces, as a reducing agent in metallurgy and in the manufacturing of various chemical substances.

2. Petroleum : The petroleum is a brown black colour oily liquid which has a special type of smell and basically it is made from various hydrocarbons (solid, liquid and gas) and sulphur whose calorific value is extremely high in comparision to the all solid and liquid fuels. The crude petroleum substances undergo the process of fractional distillation during its exploration and it ultimately splits into various hydrocarbons which are separated. The components of hydrocarbons in a fractionating column are separated at their respective boiling points. By the process of fractional distillation which is applied on the crude oil (petroleum) the following petro substances— asphalt, lubericating oil, paraffin wax, fuel oil, diesel oil, kerosene oil, petrol, petroleum gas etc are obtained.

The liquified petroleum gas (*LPG*), compressed natural gas (*CNG*) etc are the mixture of ethane, propane and butane and in it the main component is normal and iso-butane, which burns very quickly inflamebly and provides a substantial amount of heat. Actually on increasing pressure, normal and isobutene is compressed and consequently liquified and used as LPG in the cylinders for the domestic purposes.

Calorific value of the fuels : The calorific value of a fuel is the amount of heat obtained by the complete burning of 1 gram of the fuel in in oxygen. The heat produced or generated is expressed in calorie, or in Joule. The calorific value of a fuel must be high and among all uels the calorific value of the hydrogen is maximum but it is not used a fuel because its safe storage is difficult to carry out. Thus hydrogen sed as a fuel in space vehicles and in the burner which produces high perature. Hydrogen is called the fuel of the future. Some light vehicles the sophisticated technology are running on the hydrogen today.

ition temperature

The minimum temperature at which a substance begin to burn is called ition temperature.

Combustion : The process of burning of a substance in the presence of xygen which produces heat and light is called combustion. In other words e can say that the combustion is a process of chemical reaction in which eat and light is produced and heat produced is sufficient to carry forward he reaction. Also the combustion is an oxidation reaction.

ombustible and Incombustible substances

The substances which burn in the presence of oxygen or air are called ombustible substances. The substances like carbon, sulphur, candle, magnesium etc are examples of combustible substances.

The substances which cannot burn in the presence of oxygen or air are called incombustible substances. The substances like sand, stones, bricks, soil etc are examples of incombustible substances.

Favourable and Non-favourable conditions of combustion : The substance which favours the combustion process is called combustion prompter like oxygen then this is a favourable condition of the combustion otherwise it is a non-favourable condition of the combustion. Thus the necessary conditions for a combustion, three parameters — presence of combustible substance, presence of the combustion prompter (like oxygen or air) and the achievement of the ignition temperature must exist.

Types of combustion : Generally there are four types of combustion :

(i) Rapid combustion : The combustion process which takes place quickly (rapidly) in a very small interval of time in which heat and light produces is called rapid combustion. To burn a match stick, to explode a fire cracker etc. are the examples of rapid combustion.

(ii) Slow combustion : The combustion process which takes place slowly is called slow combustion. The inhalation is the best example of a slow combustion.

(iii) Auto combustion : The combustion process which takes place without the support of the external heat is called auto combustion. To burn phosphorus is an example of an auto combustion.

(iv) Explosion : The explosion is a burning process of the substance which occurs due to an external pressure. To explode a fire cracker or a bomb are the examples of explosion.

Rocket fuels : Generally those fuels are used in the rocket which have a very high calorific value, which can ignite themselves very quickly and generate an extremely large amount of heat. These fuels are also called propellant. A rocket has two types of propellants (fuels) — liquid propellant (like liquid hydrogen or liquid paraffin) and solid propellant (like gun powder). Some others liquid propellants are alcohol, liquid ammonia, kerosene, hydrogen etc.

In liquid propellant a suitable oxydiser is taken and stored up in a separate chamber where propellant is burnt out, while in solid propellant an oxydiser is attached itself. By the use of a propellant a large amount of heat is produced due to its combustion which raises the inside pressure and temperature tremendously. Thus due to a larger inside pressure raised the gases like CO, steam etc. are departured from the orifice in the back with a very high velocity stream called jet. Consequently a rocket is propelled forward opposite to the jet direction due to the momentum lost by the jet of the propellant and which is gained by the rocket.

Biogas : The residual substances are obtained from various animals, plants etc. which are decomposed by the micro organisms in the presence of moisture or water. In this process a number of gases like methane, carbondioxide, hydrogen, hydrogen sulphide etc. release. This gaseous mixture is called biogas in which the main component is methane (CH_4) and it is nearly 65%. One of the chief characteristic of the biogas is it smoothly burns and supply a sufficient amount of heat energy without any smoke, that's why it is frequently used for the domestic purposes. Also at the end of the use of biogas some complex chemical compounds of nitrogen and phosphorus are obtained as waste residue substances which are used in agriculture land as mannures and which can grow the fertility of the infertile land.

II. Inorganic Chemistry

1. Periodic classification of elements

Periodic classification : An arrangement in which the elements reappear again and again at a regular interval based upon some specific fundamental properties is called periodic classification or periodic arrangement of the elements. The main purpose of the periodic classification of the elements having the same properties is to study chemistry in a simple, convenient, transparent and a more comprehensive way.

Mendeleev's classification of elements : In 19th century various attempts were taken by the worldwide chemists for the classification of the elements. On the basis of the fundamental properties no definite classification could be done at that time. At the middle of the 19th century on the basis of a comparative study of the chemical compounds Mendeleev propounded a law which was called *Mendeleev's periodic law* stated as below—

The physical and chemical properties of the elements are the periodic functions of their atomic weights.

In other words if the elements are arranged in the order of increasing atomic weights then after a definite number there would be the elements which will have nearly the same properties.

Mendeleev arranged that time invented elements on the basis of his periodic law in a tabular form which is called periodic table. In Mendeleev's periodic table there were two types of blocks - vertical and horizontal. The vertical blocks were called groups, while the horizontal blocks were called periods. There were 9 groups and 7 periods in Mendeleev's periodic table. There were only 63 elements invented at that time when Mendeleev was composing the periodic table. Since inert gases were not invented at that time, so Mendeleev had left various empty places in his periodic table.

Advantages (Mendeleev's periodic table)

1. Convenience in the study of elements.
2. Prediction and invention of new elements.
3. Modification in the elements of ambiguish atomic weights.
4. Information about the nature of the compounds of the elements.
5. Decision about the valency of the elements.

Drawakes (Mendeleev's periodic table)

1. The position of the hydrogen remain disputed in the periodic table.
2. The position of the isotopes was not fixed in the periodic table.
3. Some element of the same properties had been kept in different groups in the periodic table, like pair of Cu and Hg, Ag and Tl, Au and Pt, Ba and Pb etc.
4. As in Mendeleev's periodic table elements were arranged according to the increasing order of the atomic weight but this rule had not been followed everywhere. For example— Iodine (at. wt. = 126.92) has been kept later of teluriam (at wt. = 127.61).
5. In 8th group the block of three elements had been kept together, which produces irregularities.
6. Rare earth elements had been kept together at one place in group III A in the periodic table.
7. There was no distinct and specific line of division in the periodic table between the metals and non-metals.

Mosely's modern periodic law : In 1931 a British chemist Mosely discovered a new specific property to study the atomic structure and it was the atomic number. Mosely asserted that the atomic number is the most fundamental property of the elements and he arranged the elements in the tabular form to classify the elements according to their increasing atomic number. He gave a periodic law on the basis of the formed periodic table which was internationally accepted by the scientist community.

Thus, Mosely's periodic law states that the physical and chemical properties of the elements are the periodic function of their atomic numbers. Also in modern periodic table which was composed by Mosely removed almost all the drawakes and discrapencies whatevers were in Mendeleev's periodic table.

Thus the electronic configuration of the elements is the most fundamental base of the modern periodic classification of the elements.

In the modern periodic table there are 7 horizontal lines (periods) and 16 vertical lines (groups) and the first member of each period is alkali metal and the last member is inert gas. The first member of the first period is hydrogen.

Period	Number of elements
1	2
2	8
3	8
4	18
5	18
6	32
7	rest elements

In Mosely's modern periodic table the elements of atomic number 58 to 71 and 90 to 103 have been kept in separate lines.

Difference between Mendeleev's periodic table and Mosely's periodic table :

Mendeleev's periodic table	Mosely's modern periodic table
1. Elements are arranged according to their increasing atomic weight.	1. Elements are arranged according to their increasing atomic number.
2. The subgroups A and B are kept under same group.	2. The subgroups A and B are kept separate.
3. There are 9 groups.	3. There are 16 groups.
4. There is no distinct and dividing line between metals and non-metals.	4. The places of metals and non-metal are separated and there is a distinctive line of division.
5. Ordinary elements and transition elements are not separately exhibited.	5. Ordinary elements and transition elements are separated.
6. Elements are not arranged on the basis of electronic configuration due to lack of it at that time.	6. Elements are arranged on the basis of electronic configuration.

Chief characteristics of the period (Modern periodic table) :

1. In the periodic table in a period from left to right the metallic properties of the elements decrease, while non-metallic properties increase.
2. In the periodic table in a period from left to right chemical reactivities of the elements firstly decrease then increase.
3. In the period the valency of the elements increases from 1 to 4, later diminishes and becomes 0.
4. In the period the number of valence electrons increases from left to right and increases from 1 to 8.
5. Generally in the period the value of electron affinity increases from left to right.
6. Also in the period the value of electron negativity of the elements increases from left to right.

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The value of ionization potential of the elements increase from left to right in the period.

The size or atomic radius of the elements decreases in the period from left to right.

The basic (alkaline) characteristic of the oxides of the elements in the period decreases.

Chief characteristics of the group (Modern periodic table)

1. The metallic property of the elements in the group increases from top to bottom .
2. The chemical reactivity of the metallic elements increases in the group from top to bottom, while the chemical reactivity of the non-metallic elements decreases in the group from top to bottom.
3. The valency of the elements of any particular group is same for all the elements.
4. The number of valence electrons are same for all elements kept in a group.
5. The value of the electron affinity of the elements decreases in the group from top to bottom.
6. Generally the value of electron negativity of the elements in the group decreases from top to bottom.
7. The value of ionization potential of the elements decreases in the group from top to bottom.
8. The size or atomic radius of the elements increases in the group from top to bottom.

Some important facts of the elements

Until total discovered elements.	112
Elements existing in nature.	88
Artificially (man made) produced elements.	24
Number of metallic elements.	90
Number of non-metallic elements.	22
The element to be found most abundantly on the earth's surface.	Oxygen
The metallic element to be found most abundantly on the earth's surface.	Aluminium
The lightest element to be found in the nature.	Hydrogen
The heaviest element to be found in the nature.	Osmium
The lightest metallic element to be found in the nature.	Lethium
The lightest non-metallic element to be found in the nature.	Hydrogen
The liquid metallic element to be found in the nature.	Mercury
The liquid non-metallic element to be found in the nature.	Bromine
The non-metal which is the best conductor of electricity.	Graphite (an allotrop of carbon)
The metal which is the best conductor of the electricity.	Sivler

The metal which is the second best conductor of the electricity.	Copper
The most malleable element to be found in the nature.	Gold
The most reactive non-metallic element to be found in the nature.	Fluorine
The most reactive metallic element to be found in the nature.	Cesium
The element having maximum ionization potential (*IP*) in the nature.	Helium
The maximum electrons acceptable element in the nature.	Chlorine
The most electro negative element in the nature.	Fluorine
The most powerful oxidising substance.	Fluorine
The group of the most gaseous elements.	Zero group
Name of monoatomic elements.	Inert gases
The most abundantly found element in the human body.	Oxygen
The element kept inside the kerosene oil.	Sodium

2. Metallurgical Operations

Metallurgy : In the extraction of metals there are various processes which directly or indirectly affect the physical and chemical activities involve in the production of metals from their respective ores is called metallurgy.

Terms related to metallurgy :

Mineral : The substances which are found abundantly in nature and in which a core chemical component (element or compound) is necessarily present is called mineral.

Ore : The ore is the mineral in which good amount of metal is present and the metal is extracted at low cost by a convenient process is called ore. For example ; iron pyrite is a mineral of iron but it can not be an ore because to extract iron from it is costly. Thus iron pyrite can not be an ore of the iron.

Elements, Ores and their composition

Elements	Symbol	Ores	Composition of Ores
Sodium	Na	Sodium chloride	$NaCl$
		Sodium carbonate	$Na_2CO_3 . 10H_2O$
		Sodium nitrate	$NaNO_3$
		Sodium sulphate	$Na_2SO_4 . 10\,H_2O$
		Borax (sodium tetra borate)	$Na_2B_4O_7 . 10\,H_2O$
Potassium	K	Potassium chloride	KCl
		Potassium carbonate	K_2CO_3
		Potassium nitrate	KNO_3
Magnesium	Mg	Magnesite	$MgCO_3$
		Dolomite	$MgCO_3 . CaCO_3$
		Carnallite	$KCl, MgCl_2 . 6H_2O$
		Epsom salt	$MgSO_4\ 7H_2O$

Elements	Symbol	Ores	Composition of Ores
Calcium	Ca	Calcium carbonate	$CaCO_3$
Aluminium	Al	Bauxite	$Al_2O_3 . 2H_2O$
		Cryollite	Na_3AlF_6
		Corundom	Al_2O_3
		Dyspore	$Al_2O_3 . H_2O$
Copper	Cu	Cuprite	Cu_2O
		Azurite	$2CuCO_3 . Cu (OH)_2$
		Malcite	$CuCO_3 . Cu (OH)_2$
		Calcosite	Cu_2S
		Chalcopyrite	$CuFeS_2$
Tin	Sn	Cisiteryte	SnO_2
Lead	Pb	Galena	PbS
		Cirusite	$PbCO_3$
Silver	Ag	Native silver	Ag
		Arzentite	Ag_2S
Zinc	Zn	Zinc blend	ZnS
		Calamin	$ZnCO_3$
		Zincite	ZnO
Mercury	Hg	Cinebar	HgS
Manganese	Mn	Pyrolucite	MnO_2
		Manganetite	$Mn_2O_3 . H_2O$
Iron	Fe	Haemetite	Fe_2O_3
		Magnetite	Fe_3O_4
		Ciderite	$FeCO_3$
		Iron pyrites	FeS_2
		Chalco pyrites	$CuFeS_2$
Barium	Ba	Heavy spar or Bariots	$BaSO_4$
		Bithrite	$BaCO_3$
Cadmium	Cd	Grinocite	CdS
Chromium	Cr	Chromite	$FeO Cr O$
Arsenic	As	Arseni	

Gangue or Matrix : The ore from which metals and its compounds are obtained has some impurities in it is called gangue or matrix.

Smelting : The process of heating an ore above its melting point with coke and flux in order to fuse the whole mixture and reduce the ore to metal is called smelting. The smelting is a chemical changing process.

Flux : The substance which is added from outside in the ore during the process of smelting to remove gangue (impurities) is called flux. In fact some infusible materials are to be found in the ore which becomes fusible at very high temperature by the chemical reaction which takes place after adding some extraneous material.

In the smelting of iron, lime stone ($CaCO_3$) is used as a flux, because on heating in blast furnace it gives CaO which ultimately provides calcium silicate ($CaSiO_3$).

Slag : The substance which is the light, fusible and waste material obtained during the extraction of metals by the chemical combination of gangue and flux is called slag. The slag being lighter and fusible, floats on the surface of the molten metal.

Iron ore contains $Si\,O_2$, P_2O_5 etc as impurities. If $CaCO_3$ is added to the red hot haemetite ore in the blast furnace then at about 1000°C, $CaCO_3$ breaks and CaO is formed which combines with SiO_2 and P_2O_5 to form a fusible light waste substance called slag.

Thus;

$$\underset{\text{gangue}}{SiO_2} + \underset{\text{flux}}{CaO} \longrightarrow \underset{\text{slag}}{CaSiO_3}$$

$$\underset{\text{gangue}}{P_2O_5} + 3CaO \longrightarrow \underset{\text{slag}}{Ca_3(PO_4)_2}$$

If the gangue (impurities) is basic then flux like silica (SiO_2) is used.

Calcination : The process by which the volatile impurities of the ores are removed by strong heating is called calcination. In this process the presence or absence of the air doesn't matter but only the chemical reaction occurs in such a way that decomposable oxides of the oxysalts only produce.

Roasting : The process of heating of the ore below its melting point in such a way in which it is heated at a constant temperature through a controlled air supply is called roasting. Also in this process impurities like sulphur, arsenic etc become oxidised and the converted volatile oxides escape, while metallic oxides only remain confined ultimately.

Concentration of ore : The process of separation of the gangue (impurities) or matrix from the ore is called concentration of ore.

The process of concentration of the ores—

(i) Hand picking (ii) Gravity separation process (iii) Oil floatation process (iv) Magnetic concentration process (v) Leaching process.

The ores of more density are separated by the gravity separation process, sulphides ores are separated by the oil floatation process, while the impurities of the ores are removed by the magnetic concentration process.

Refining : The extraction process of the pure metals from impure metals under the suitable condition is called refining of metals. The refining process of impure metals depends on the nature of element and the nature of the impurities present.

3. Metals

The element which loses electrons and provides cations is called metal. In the periodic table almost all metals are located towards left and middle. Also the elements which are located extremely left have the most metallic properties.

Primitively there were three metals namely *Cu, Ag, Au,* specially in the proto historic era, but at present there are 90 metals.

Properties of the metals—

(A) Physical properties

1. Metals are malleable, a number of thin foils can be drawn by hammering. Gold and silver are the two most malleable metals.
2. Metals are ductile also, but all are not equally ductile, and the most ductile metal is silver. For example from 100 mg silver a 200 metre long ductiled wire can be formed.
3. All metals shine and it is called metallic lusture.
4. Almost all metals are good conductor of the heat and electricity. Silver and copper are the two best conductors of the heat and electricity. But lead is the least good conductor of the heat and electricity.

(B) Chemical properties

Metals usually react with various non-metals like oxygen, hydrogen, chlorine, sulphur etc. and form compounds. More reactive metals react with water at ordinary temperature, while less reactive metals react with hot water or water vapour. Metals easily react with acids and bases.

Metals, ores, extraction of metals and utilities of some important chemical compounds.

Sodium

Symbol - Na, Atomic Number— 11, Mass Number— 23

The place in periodic table— IA, period— 3rd, Element (Na)— *s* block (alkali metal). Electronic structure— $1s^2, 2s^2 2p^6, 3s^1$.

Occurrence and extraction : Due to highly reactive element it does not exist freely in nature, but it is found in the form of ores of chloride, nitrate, carbonate, borate etc.

Sodium metal is extracted by Castner's process from the electrolysis of molten sodium hydroxide (NaOH). Also on the large scale, extraction of sodium is followed by Down's process in which sodium is obtained from the electrolysis of sodium chloride (NaCl).

Physical and chemical properties : Sodium is white like silver, but it is very soft and light, so it can be cut through knife and floats in water. Due to a highly reactive nature sodium is kept inside the kerosene oil (K-oil). But sodium is soluble in benzene and ether.

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Sodium doesn't react at an ordinary temperature in dry air, but it moist air it reacts and forms sodium oxide (Na_2O). That's why sodium i kept inside the K-oil. Sodium reacts fastly with water and forms sodium hydroxide (NaOH) and hydrogen gas (H_2). It reacts with ammonia (NH and forms sodamide. It forms sodium alcoxide and hydrogen gas by reacting with alcohol. Sodium also reacts with acids and form salts and releases hydrogen gas.

Uses :

(i) As a reducing agent

(ii) In synthetic reactions

(iii) In making tetraethyl lead (anti knocking) compound by the use of an alloy of sodium-lead.

(iv) The fused or molten sodium is used as a coolant in the nuclear reactors.

Compounds :

1. Sodium hydroxide (NaOH) : The compound NaOH is called caustic soda which is used as a petroleum purifier, in manufacturing of soaps, to produce glazing in pulp paper, cotton cloth etc, in the production of the artificial silk, in making colour and rayon, as a laboratory reagent, in the extraction of sodium etc.

2. Sodium carbonate (Na_2CO_3) : The deca hydrated sodium carbonate ($Na_2CO_3 . 10H_2O$) is called washing soda. On the extensive level Na_2CO is produced by various processes like Le–Blanc's process, Solvey's process (ammonia - soda process), electrolytic process etc.

Sodium carbonate is extensively used in removing hardness of water, as a petroleum purifier, as a laboratory reagent, in the production of water glass, soap, pulp paper, caustic soda etc. The aqueous solution of the washing soda is alkaline that's why sometimes it is also used as a detergent.

3. Sodium bicarbonate ($NaHCO_3$) : This is called baking soda. When this baking soda is mixed up in the wheat flour in very small amount through which the breads are to be prepared then the breads are exposed properly (fully). That's why it is also called *edible soda,* and breads get such exposer by an emergent gas CO_2.

Sodium bicarbonate are frequently used in manufacturing of various drugs, in removing acidity from human stomach, in making fire extinguisher etc.

4. Globar Salt (Na_2SO_4 . 10 H_2O) : This compound is prepared by the reaction of NaOH or Na_2CO_3 on the sulphuric acid (H_2SO_4) and it is a crystallined colourless solid substance.

This compound is used in the production of water glass, pulp paper in the manufacturing of drugs, in the preparation of sodium sulphide etc.

5. Sodium chloride (NaCl) : This is called common salt or ordinary salt which is prepared by the vaporisation process of sea water. The freezing mixture is prepared by mixing sodium chloride with ice at a lower pressure and a moderate temperature.

Sodium chloride is the most important component of the human's food composition. Normally in sea water among all soluble salts about 75% salt is sodium chloride. During the symptoms of dehydration, loose motion or vomiting the level of common salt is abruptly down falls in the human body. In open atmosphere the common salt absorbs moisture from the atmospheric air and the impurity like magnesium chloride ($MgCl_2$) appears in it.

6. **Sodium peroxide (Na_2O_2) :** This is an yellowish powder which is very light and when left in open air then a layer of hydroxide and carbonate is formed on it and it turns white.

Sodium peroxide is used in the preparation of hydrogen peroxide (H_2O_2), in colouration, as an oxidising and a reducing agent, in the bleaching of silk and woolen garments. Also this compound is frequently used in the manufacturing of submarines, ships and in purifying closed air as that of anywhere like of hospitals, auditorium etc.

7. **Sodium nitrate ($NaNO_3$) :** This is called chile saltpeter and this compound is abundantly found in Chile and Peru. This is used as a fertiliser and in the production of nitric acid (HNO_3).

8. **Sodium thiosulphate ($Na_2S_2O_3.5H_2O$) :** Commercially it is called hypo which is used frequently in photography. When the photographic reel is developed then photo of the film is prepared and there is a need of fixation of the positive and negative of the film which is done by the hypo. The hypo in fact strongly reacts with undercomposed silver bromide (AgBr) in which solution photographic film is washed out. The hypo is also used as an antichlor which removes chlorine from the bleached garments. The hypo is also used in the extraction of Silver and Gold.

9. **Borex–Sodium tetra borate deca hydrate ($Na_2B_4O_7 . 10\,H_2O$) :** This is a white crystalline solid which is soluble in water. It is mainly used in manufacturing glass, soap, candle etc., in the glazing process of pulp-paper and ceramic substances, in softening water, in leather industry to bleach the skin layer and in the colouration of leather.

10. **Microcosmic salt :** The complex compound sodium ammonium hydrogen phosphate is called microcosmic salt.

11. **Calgen : [$Na_3\,(PO_3)_6$] :** The complex compound sodium hexa meta phosphate is called Calgen. This is used in removing the hardness of water.

Nelson's cell is used in manufacturing of sodium hydroxide (NaOH).

The compound (salt) of sodium provides an yellow colour which is permanent and used in bunsen burner non-luminous flame. The value of the ionisation potential is low that's why the bunsen burner supply a fascinating yellow colour.

Magnesium

Symbol : Mg, Atomic Number– 12, Mass Number– 24, Element (Mg)– s block (light metal, bridge element).

The place in the periodic table– II A

Period– 3rd

Electronic structure ; $1s^2, 2s^2 2p^6, 3s^2$.

Occurrence and extraction : The metal magnesium doesn't exist in nature in free state because it is highly reactive. Generally in the form of sulphates and chlorides compounds (alloys) this metal is found. The organic compound Chlorophyll which provides green colour to the leaves of the plants has mainly magnesium element within itself.

This metal (magnesium) is mainly extracted from its ore carnallite ($KCl . MgCl_2 . 6H_2O$) by the means of electrolytic process.

Physical and Chemical properties : This is a white and extremely glazed metal like silver. The metal magnesium is malleable and ductile that's why it can easily be transformed into thin wire or ribbon. The b.p and m.p of this metal is 650°C and 110°C.

This metal easily reacts with dilute acids and hydrogen gas is formed. But it does not react with base. In the presence of dry ether it directly reacts with ethyl iodide or bromide and ethyl magnesium iodide or bromide is formed which is called Grignard's Reagent.

Uses : The metal magnesium is used in making flash light ribbon, in photography and in fire crackers, in the composition of alloys etc.

Alloys :

Magnelium— Mg (2%), Al (95%), Cu - Fe (2-3%).

Duralumin— Al (94%), Cu (4%), Mg (0.5%), Zn (4.5%), Mn (0.5%).

Elektron— Mg (95%), Zn (4.5%), Cu (0.5%).

The alloy magnelium is too light that's why it is frequently used in manufacturing of aircrafts and commercial wt. balance. The ore duralumin is also light and soft which is used in the manufacturing of aircrafts, pressure cooker etc. The alloy elektron is frequently used in making the frames of aircrafts and motor vehicles.

The magnesium ribbon is kept inside in the flash bulbs in which atmospheric nitrogen is filled up.

Compounds :

1. Magnesia (MgO) : The magnesia (MgO) is also called milk of magnesia which is a white coloured powder. This is slightly soluble in water, it is fluorescent to the light and it is fused at a very high temperature, that's why magnesia is used in layer lining of blast furnace. The magnesia is also used in removing acidity from the human stomach.

2. Magnesium hydroxide [Mg $(OH)_2$] : This is a white coloured substance which is slightly soluble in water. This is a base and used in the production (extraction) of the sugar from molasses.

3. Magnesium sulphate ($MgSO_4$) : This compound naturally occurs in the form of epsomite in epsome which are abundantly found in hot water spring. This is a colourless crystalline solid substance. This is frequently used in cotton industry, in the manufacturing of soap, paint etc. This is also used as a catalyst with platinum in the manufacturing or production of sulphuric acid (H_2SO_4). This is used as a purgative and epson salt ($MgSO_4.7H_2O$) in a deliquescent compound.

4. Magnesium carbonate ($MgCO_3$) : This compound occurs naturally in the form of manganesite or dolomite which is a white solid substance soluble *in water.* **Magnesium carbonate** is used in the production of printing ink, *toothpaste,* face cleaning powder etc. This is also used as magnesium alva *in the form* of drug. This is also used in removing acidity from the human *stomach.*

5. **Magnesium alva [Mg $(OH)_2 . MgCO_3 . 3H_2O$] :** This compound it *used* in removing the acidity from the human stomach and it is infact an *antacid.*

6. **Sorel cement : ($MgCl_2 . 5MgO . nH_2O$) :** This complex compound is *used* in house construction, bridge construction etc.

Aluminium

Symbol— Al, Atomic Number– 13, Mass Number– 27.

The place in periodic table– III A, period– 3rd,

Element (Al)— *p* block.

Electronic structure— $1s^2\,2s^2\,2p^6\,3s^2\,3p^1$.

Occurrence and extraction : Aluminium doesn't occur in nature in free state but occurs in the forms of compounds like bauxite ($Al_2O_3 . 2H_2O$), Corundum (Al_2O_3), diaspore ($Al_2O_3 . H_2O$), felspar ($K_2O . Al_2O_3 . 6SiO_2$), mica ($K_2O . 3Al_2O_3 . 6SiO_2 . 2H_2O$), Kaolin ($3Al_2O_3 . 6SiO_2 . 2H_2O$), Cryollite ($Na_3AlF_6$) etc. Aluminium is the most abundantly occurring metal in the earth crust. After oxygen and silicon this is the third element which occurs so abundantly in large amount. The main ore of it is bauxite.

Aluminium is mainly extracted from bauxite by the means of electrolytic process. The chemical name of bauxite is hydrated alumina. In the extraction of it by electrolytic process cryollite is used in dissolving bauxite at a lower temperature.

Physical and Chemical properties : This is a white glazing metal like silver and its m.p. and b.p. are 659.8°C and 2200°C, while its specific gravity is 2.7. This is a good conductor of heat and electricity and it is malleable and ductile.

Aluminium reacts strongly with conc. HCl and provides hydrogen gas and aluminium chloride, but with dil. H_2SO_4 it reacts slowly providing H_2 gas while with conc. H_2SO_4 it forms $Al_2(SO_4)_3$ and SO_2 gas. With NaOH or KOH it forms aluminate salt and H_2 gas emerges out. Also with nitrogen it forms aluminium nitride.

Uses : This metal (aluminium) and its alloys are frequently used in aircrafts, motor vehicle industries. The cooking utensils are manufactured by the alloys of it and by the metal itself. The electric wires are also made from aluminium and thin foil of it are today used in decorating sweets (confectionaries), in packaging of cigarette etc. This metal is also used as a reducing agent for metal oxides of iron, manganese etc.

Alloys, compositions and uses :

Alloys	Composition	Uses
Aluminium bronze	Al (10%), Cu (90%)	In making kitchen utensils, coin etc.

Alloys	Composition	Uses
Magnelium	Al (95-96%), Mg (2%), CuFe (2-3%)	In manufacturing of aircrafts.
Nickelloy	Al (90%), Ni (6%), Cu (4%)	In making aircrafts.
Duralium	Al (95%), Cu (4%), Mn (0.5%), Mg (0.4%)	In manufacturing of aircrafts and pressure cooker.

Compounds

1. Aluminium chloride ($AlCl_3$) : This is used as a catalyst in Friedel Craft reaction which occurs on an extensive level. This is also used as a catalyst in the production of Gasoline. It is also used in cracking of petroleum anhydrous $AlCl_3$.

2. Alumina (Al_2O_3) : This occurs in nature in the form of bauxite, corundum etc. It is also found in the form of gems. On large level it is manufactured by the bauxite ore. This is white and incrystallined and soluble in water. Also Al_2O_3 is an amphoteric oxide, thus reacts with both acid and base.

This is used frequently in the production of artificial gems, in the preparation of aluminium and its various complex compounds, as a catalyst, in layer lining of blast furnace etc.

3. Potash alum [$K_2SO_4 . Al_2(SO_4)_3 . 24\,H_2O$] : This is a double salt which appears as a colourless crystalline solid. This is also used in pulp-paper and leather industries, as an anticeptic and as a germicide after shaving, as a germicide for purification of water etc.

4. Aluminium carbide (Al_4C_3) : This is also called methanide. When the water is poured on the aluminium carbide methane gas is formed.

5. Aluminium hydroxide [$Al(OH)_3$] : This is a white amorphous powder insoluble in water and it is a covalent compound. This is used in making fire proof and water proof cloths, in the name of aluminium Gel, it is used as a drying agent, freshly precipitated $Al(OH)_3$ absorbs colouring matter forming insoluble lakes.

6. Aluminium sulphate [$Al_2\,(SO_4)_3$] : This is also called hair salt. This is used in printing, designing and colouration of cloths in the form of mordant. It is also used in making potash alum.

Calcium

Symbol— Ca, Atomic Number– 20, Mass Number– 40,
The place in the periodic table period– IV,

Element (*Ca*)— *s* block (alkaline earth metal)

Electronic structure— $1s^2, 2s^2 2p^6, 3s^2 3p^6, 4s^2$.

Occurrence and extraction : This metal doesn't occur in free state in nature but occurs abundantly in the form of compounds of carbonate, sulphate, silicate, phosphate etc. This metal is also found in bones, snail (member of molsc community) and it is the main component of the milk.

Calcium is extracted from the electrolytic process of the fused mixture of anhydrous $CaCl_2$ (80%) and CaF_2 (20%). CaF_2 lowers down the m.p. of anhydrous $CaCl_2$ and thus maintains a constant working temperature.

Physical and Chemical properties : This is a white metal like silver and it is soft with comparison to the other metals but hard with comparison to the lead. The b.p. and m.p. of this metal are 851°C and 1439°C, while its relative density is 1.55. This metal also exhibits the phenomenon of malleability and ductility.

Calcium reacts with acids and hydrolyses the water and consequently hydrogen gas is liberted. It doesn't react with any base or alkali.

Uses : This metal is used in removing water which is present in small amount in alcoholic solution. It is also used in removing elements like nitrogen, sulphur, oxygen etc. which are present in small amount during the process of metal extraction.

Compounds :

1. Calcium oxide (CaO) : This is also called quick lime. This is basically a white porous solid substance which reacts rapidly with water and calcium hydroxide is formed. This is used as a drier, as a mortar in the construction of houses, buildings, bridges etc. in the production of lime light and in the production of various chemicals.

2. Calcium hydroxide [Ca $(OH)_2$] : This is also called slaked lime and it is obtained by reacting quick lime (CaO) with water. It is a white powder which is slightly soluble in water, but if on dry slaked lime chlorine gas is poured then bleaching powder [Ca (OCl) Cl] is formed.

This is used in the purification of coal gas, in the production of lead, bleaching powder, caustic soda, mortar, cement etc and in whitewashing of houses.

3. Calcium chloride ($CaCl_2$) : This occurs in a very small amount in sea water and occean. It is basically a colourless, crystalline solid substance in which each molecule has six crystals of water. This is soluble in alcohol and water. This is deliquescent and used as a water absorbing substance or as a dehydrating agent. This is also used as an ice mixture.

4. Bleaching powder [Ca (OCl) Cl] : This is an oxichloride of calcium and it is produced on large scale by Hasen Clever's process. It is prepared by supplying chlorine gas on the solid slaked lime and it obtained as a white powder whose smell is that of chlorine. It is an extremely temporary compound used in bleaching action of paper and cloth or garment. This is also used as an insecticide or a germicide, as a water purifier and as an anti-infectionent.

5. Gypsome ($CaSO_4 . 2H_2O$) : This is a solid crystalline substance in which every molecule has two crystals of water. When gypsom is strongly heated upto 120°C then it transforms into plaster of paris. Gypsom is used in making plaster of paris and ammonium sulphate which is a fertilizer.

6. Plaster of paris ($CaSO_4 . 1/2\ H_2O$) : This is a semihydrated calcium sulphate which is a white powder insoluble in water. It strongly and fastly reacts with water and consequently heat is produced and temperature is raised. It is used in bandage in the surgical process, used in manufacturing of statues (idols) and in the frames of statue etc.

7. Superphosphate of lime [$CaH_4(PO_4) + CaSO_4 \cdot 2H_2O$]: The mixture of mono calcium hydrogen phosphate and sulphate is called super phosphate and it is prepared from phosphorite and also from the bones of animals. This is soluble in water and so plants and trees absorb easily. This is used as a good fertiliser.

8. Calcium Carbide (CaC_2) : This is prepared by heating quicklime (CaO) with coke at about 2000°C in an electric furnace. It is a slate coloured solid and it reacts with water and forms acetylene (C_2H_2). This is used in making oxy-acetylene flame for lightning purpose, used as a fertiliser.

9. Nitrolim ($CaCN_2$) : This is calcium cyanamide ($CaCN_2$) and obtained on heating from calcium carbide (CaC_2) at 2000°C in a current of nitrogen gas. It is used as a nitrogeneous fertiliser.

10. Hydrolith (CaH_2) : This is a solid substance and chemically it is calcium hydride (CaH_2) which is prepared by heating calcium in hydrogen gas. When solid CaH_2 is treated with water, H_2 gas is evolved, that's why hydrolith is used as a ready supply of H_2 gas.

11. Calcium Carbonate ($CaCO_3$) : This occurs in nature in the form of lime stone, marble, slaked lime etc abundantly. It is present in dolomite along with magnesium carbonate. It is a white solid insoluble in water. It is frequently used in tooth powder, tooth paste, in white washing on the walls of the houses and in cement industries.

12. Calcium Phosphate [$Ca_3(PO_4)_2$] : This is used frequently in the production of tooth paste.

Manganese

Symbol— Mn, Atomic Number– 25, Mass Number– 55,

The place in the periodic table– VII B, period– 4th

Element (Mn)— *d*-block

Electronic Structure— $1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^5, 4s^2$.

Occurrence and extraction : It does not exist free in nature but it is found in the form of compounds of minerals or ores. This is extracted from a main ore called pyrolusite.

Compounds :

1. Potassium permanganate ($KMnO_4$) : This is a bluish coloured crystalline solid substance which is also called red medicine. On the extensive level its production is done by the ore of manganese pyrolusite. The crystal of $KMnO_4$ is of blue colour which has a metallic lustre. This is slightly soluble in water and forms a solution of reddish colour. This provides potassium magnet and manganese dioxide. It is used as an oxidising agent on the large scale in volumneous analysis. This is also used in examing double bonds of organic compounds. This is also used as a bleaching agent for woolen, silk and cotton garments. This is used as colour remover of oils and as a germicide or an insecticide of water.

2. Manganese dioxide (MnO_2) : This is used in dry cells which are used in various electronic devices like torch, radio, transistor etc.

Iron

Symbol— Fe, Atomic Number– 26, Mass Number– 56,
The place in the periodic table– VII, period– 4th
Element (Fe)— *d*-block
Electronic Structure— $1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^6, 4s^2$.

Occurrence and extraction : This is a transition metal and it doesn't occur in nature in free state but it is found in the form of ore. It has fourth position among all the elements found on the earth's crust. In nature it is also found abundantly in green vegetables and in the haemoglobin of the blood. There are various ores which naturally occur in nature and mainly these are red haemetite (Fe_2O_3), brown haemetite ($2Fe_2O_3 . 3H_2O$), magnetite (Fe_3O_4) etc.

Most of iron is extracted from red haemetite (Fe_2O_3) in the blast furnace by carbon-reduction process.

Varieties of iron

1. **Cast iron or Pig iron :** In this variety of iron the amount of carbon (2.5%) is comparatively high and that's why such iron is hard and brittle. Also in it very small amount of impurities like phosphorous, silicon, manganese etc. are found and such iron is of lower quality. This is of two types– white cast or pig iron and brown cast or pig iron. In white cast iron almost all carbon is in a complex form, while in brown cast iron almost all carbon is confined in the form of micro crystals of the graphite and distributed in the entire body. It is used in the manufacturing of steel, wrought iron and in foundry work. It is also used in making utensils, type-writer-cover etc.

2. **Wrought iron :** This is obtained directly from cast iron or pig iron and it is comparatively a pure metallic iron. This is malleable and ductile that's why foils, sheets and wires are made. The amount of carbon is very low (0.12 - 0.25%) in the wrought iron.

3. **Steel :** This is basically an alloy of iron and carbon. In it the amount of carbon is less than that of cast or pig iron. Thus in steel the amount of carbon is 0.25 to 1.5%. There are usually four types of it.

(a) Mild Steel : In this steel the amount of carbon (0.1%) is very low and it is malleable and ductile that's why metallic sheets and wires are made from it.

(b) Medium Steel : In this steel also the amount of carbon (0.5%) is low but it is comparatively hard and it is used in the manufacturing of rail track, bridge, aircrafts etc.

(c) Hard Steel : In this steel the amount of carbon is 1.5% and it is used in making tools, equipments etc.

(d) Alloy Steel : There are various name of alloy steel like stainless steel, chrome steel, manganese steel, tungsten steel etc. In ordinary iron steel, only iron and carbon are mixed up, but if metals like chromium, manganese, nickel etc are added in small amount then it is called alloy steel. The best example of alloy steel is stainless steel and on it there is no effect of air, water, moisture etc so remains free from rusting.

Tempering of Steel : When red hot steel is emerged in water or oil and quickly cooled down then the steel becomes extremely strong and brittle. This process is called hardination of steel and this steel is called quenched steel. Again if this steel is made cool slowly and steadily then it becomes elastic and brittle and it is called annealination of steel.

The process of hardination after which the process of annealination is achieved then jointly both processes are called tempering of steel.

Alloys of Steel

Steel	**Special composition**	**Special feature or properties**	**Uses**
Stainless steel	Cr (12-15%)	Very hard and strong, doesn't form rust.	Used in making cooking utensils, surgical instruments, blades etc.
Manganese steel	Mn (6-15%)	Very hard and less rubable, free from rusting.	Used in making railway tracks, switches, axels and cutting tools.
Chrome steel	Cr (5%)	Extremely hard and strong.	Used in making safe vaults, ball bearings, jaws of stone crushing machine.
Invar	Ni (36%)	Absenceofexpansion characteristic.	Used in making pendulumsofwatches, scales, yard stick etc.
Nickel steel	Ni (3-4%)	Very hard and elastic, free from rusting.	Used in making axels, electric wire, aircraft, auto parts etc.
Tungsten steel	W (10-20%)	Very hard strong.	Used in making spring, magnets saws, axels and cutting tools.
Chrome Vanadium steel	Cr (1-10%) V (0.15-0.5%)	Has high tensile vanadium steel strength and load bearing capacity.	Used in making ball bearings, gears and axels.

Physical and Chemical properties of iron : Pure iron is like a silver white, soft, ductile, and malleable metal. The specific gravity of iron is 9.85, its m.p. and b.p. are 1533°C and 2450°C. It is a transition metal and ferromagnetic and it is attracted by the magnet.

Iron doesn't react with dry air at ordinary temperature, but it reacts with moist air and rust is formed. Pure iron doesn't react with pure water, but it reacts with ordinary water and rust forms. On passing water vapour on a red hot iron fersoferric oxide and H_2 gas are formed. It also reacts with halogen and sulphur and form halide and sulphide. It doesn't react with bases or alkalies. It easily reacts with hot and conc. H_2SO_4 and ferous and ferric sulphate, SO_2 gas are formed. It also reacts with cold and dil. HNO_3

ferrous nitrate and ammonium nitrate are formed. But with conc. HNO_3 reacts and form ferric nitrate and nitrogen peroxide gas.

Passivity of iron : If in a chemical reaction a thin layer of fersoferric oxide (Fe_3O_4) is formed on the iron then it doesn't react with substance like HCl or dil. H_2SO_4 and it is called passive iron. To make the passive iron again active it is heated in the flow of H_2 gas.

Rusting of iron : When iron is kept open in the moist air then upon it and loosened layer appears which is called rust and the process is called rusting of iron. The rusting occurs due to the moisture and oxygen of the air. There are various processes to protect the iron from rusting but the most appropriate process is galvanisation in which zinc is coated.

The rusting of the iron is an example of chemical change. Due to rusting the weight of the iron is increased. The rust in the iron is fersoferric oxide due to it a deep brown loosened layer appears on the outer surface. The galvanised iron sheet has a thin layer coated with zinc.

Compounds of iron

1. Ferrous sulphate ($FeSO_4$) : The hydrated ferrous sulphate is called green vitriol ($FeSO_4 . 7H_2O$). This is a light green crystalline solid highly soluble in water. This is used in making inks, dyes, Mohr's salt etc. The dry salt (compound) of ferrous sulphate is used in manufacturing of iron deficient drugs.

2. Ferric chloride ($FeCl_3$) : The hydrated ferric chloride is a brownish black crystalline solid highly soluble in water, while anhydrous ferric chloride is a hydroscopic (water absorber) yellowish powder. It is used as a laboratory reagent, in the production of blood coagulating medicines.

3. Iron sulphide or ferrous sulphide (FeS) : This is a called fake gold or gold of tools. It is used in preparation of hydrogen sulphide (H_2S) gas in the laboratory through Kipp's apparatus.

4. Mohr's salt [$FeSO_4 . (NH_4)_2SO_4 . 6H_2O$] : This is a green colour crystalline solid soluble in water but insoluble in alcohol. This is used in volume synthesis, in making blue ink, in colouration of leather, garment etc, as an insecticide, as a reducing agent in the laboratory.

The cause of disease anaemia is the deficiency of iron, while disease siderosis occurs due to excess intake of iron. The tribal people (Bantu tribes) of Africa are generally found to be suffering from siderosis due to excess consumption of bear in iron utensils.

On large scale the steel is manufactured from the pig or cast iron by Bessemer-converter process.

The steel of maximum carbon content is used in making rassear and its axel. The steel is also used in making permanent magnets.

Copper

Symbol— *Cu*, Atomic Number— 29, Mass Number— 64,

The place in the periodic table— IB, period— 4th

Element (Cu)— d block (coinage metal)

Occurrence and extraction : Copper occurs in nature in the form of ma as well as in the forms of its ores. In the form of ores it is found as copper pyrites ($CuFeS_2$), copper glance (Cu_2S), cuprite (Cu_2O) azurite [CuC . $Cu(OH)_2$] etc. It is a transition element and used in making household utensils, alloys and coins, so it is also called coinage metal. This is mainly extracted from copper pyrites ($CuFeS_2$) ore by means of self reduction process.

Physical and Chemical properties : This is a tough reddish colour metal whose specific gravity is 8.95 and its m.p. and b.p. are 1083°C and 2310°C. It is malleable and ductile. This is a good conductor of heat and electricity.

At an ordinary temperature it doesn't react with dry air, but in moist air it forms basic carbonate slowly and steadily. It does not react with dil HCl, but reacts with conc. HCl and Cupric chloride ($CuCl_2$) is formed. It doesn't react with cold and dil. H_2SO_4, but with hot and conc. H_2SO_4 forms SO_2 gas. It reacts with dil. HNO_3 and forms nitrous oxide (N_2O) gas, while with 50% conc. HNO_3, nitric oxide (NO) gas is formed. But if it reacts with conc. HNO_3 then NO_2 gas is formed. If the vapour of HNO_3 is passed on hot copper than nitrogen (N_2) gas is formed.

Uses : It is used in manufacturing of electric wires and electrical appliances, in electro typing and electro plating, in the production of domestic utensils, coins, alloys, calorimeter etc.

Alloys of copper

Alloys	**Composition**	**Uses**
Brass	Cu (70%), Zn (30%)	Used in making idols, household utensils, etc.
Bronze	Cu (88%), Sn (12%)	Used in making coins, idols, bells, utensils etc.
German silver	Cu (60%), Zn (25%), Ni (15%)	Used in making idols and utensils.
Rolled Gold	Cu (90%), Al (10%)	Used in making cheap ornaments.
Monel metal	Cu (70%), Ni (30%)	Used in making alkali resistant containers.
Bell metal	Cu (80%), Sn (20%)	Used in making bells, utensils, idols, coins etc.
Gun metal	Cu (88%), Sn (10%), Zn (2%)	Used in making engineering goods, gun, parts or equipments of machine.
Delta metal	Cu (60%), Zn (38%), Fe (2%)	Used in making propellers of ships, as resistant of sea water.
Munz metal	Cu (60%), Zn (40%)	Used in making coins, tubes and casting etc.
Dutch metal	Cu (80%), Zn (20%)	Used in making cheap ornaments due to its golden yellow colour.
Constanton	Cu (60%), Ni (40%)	Used in making electrical apparatus, tools etc.

Compounds

1. Cupric sulphate ($CuSO_4$) : This is the main compound of copper it is also called blue vitriol ($CuSO_4 \cdot 5H_2O$). This is basically a solid crystalline substance of blue colour in water. Its aqueous solution is acidic to litmus because it gets hydrolysed with water and $Cu(OH)_2$ and H_2SO_4 are formed. Copper sulphate is a poison and that's why it is used as a germicide or an insecticide. This is also used in electroplating, in electric cells, in refining of crude copper, in preparing green dyes. A mixture of $CuSO_4 \cdot 5H_2O$ and $Ca(OH)_2$ is called *Bordeaux Mixture* and it is used as a fungicide. Anhydrous copper sulphate is colourless or white and a little amount or even a few drops of water make it blue that's why anhydrous copper sulphate is used to examine the presence of water.

2. Cupric chloride ($CuCl_2 \cdot 2H_2O$) : This is a green crystalline solid soluble in water. It is a covalent compound and its solution is acidic in nature because it is a normal salt of weak base (CuO) and strong acid (HCl). When it is heated at 150°C it becomes dehydrated. This acts as a mild oxidising agent and in preparing Cl_2 by Deacon's method it is used as a catalyst.

3. Cuprous oxide (Cu_2O) : This is a red colour solid substance, insoluble in water. It is obtained as a red precipitate by heating $CuSO_4$ with glucose and NaOH solution. This is used in making ruby glass and in manufacturing of dyes.

4. White bronze : The bronze in which there is an excess amount of tin (*Sn*) with copper is called white bronze.

5. Fehling's solution : This is a deep blue solution obtained by dissolving $CuSO_4 \cdot 5H_2O$ solution in water by adding sodium potassium tartarate solution to it and making the resulting solution alkaline with NaOH. This is used to examine an aldehyde. When a few drops of an aldehyde is added to Fehling solution and warmed, a red ppt. of Cu_2O is obtained which is the indication of the presence of an aldehyde.

Silver

Symbol— Ag, Atomic number— 47, Mass Number— 108,

The place in the periodic table— IB, period— 5th.

Element (Ag)— *d*-block (coinage metal)

Electronic Structure— $1s^2\ 2s^2 2p^6\ 3s^2 3p^6 3d^{10}\ 4s^2 4p^6 4d^{10}\ 5s^1$.

Occurrence and extraction : It occurs as a metal in nature as well as in the forms of ores. There are various ores of silver like argentite (Ag_2S), horn silver (AgCl), pyragyrite (Ag_3SbS_3) etc.

Almost all silver is extracted from argentite (Ag_2S) ore by Mac Arthur Cyanide process. But on commercial level silver is extracted as a bye-product during the extraction of gold in India .

Physical and Chemical properties : This is a white shining solid metallic substance, malleable and ductile. This is the best conductor of heat and electricity. The relative density of it is 10.47 while its m.p. and b.p. are 960°C and 1955°C.

Dry and H_2S free air has no action on silver, but when exposed to air, it slowly turns blackish due to the formation of Ag_2S on its surface by the action of H_2S present in air. It doesn't react with any base and hydrochlori acid. In presence of air silver dissolves in sodium cyanide (NaCN) and forms sodium argento cyanide solution. It reacts with dil. HNO_3 and and nitric oxide (NO) is formed, while with conc. HNO_3, NO_2 gas is emerged. It doesn't react with dil. H_2SO_4 but with conc. H_2SO_4 when it is heated, SO gas is formed.

Uses : Silver is used in making ornaments, utensils, coins, silver pt. alloy, in filling of tooth cavities, silver plating etc.

Compounds :

1. Silver chloride (AgCl) : This is called Horn silver which is frequently used in making photochromatic glass.

2. Silver bromide (AgBr) : It is used in photography

3. Silver iodine (AgI) : It is used in producing artificial rains.

4. Silver nitrate ($AgNO_3$) : This is the main compound of the silver and it is also called *Lunar Caustic*. This is prepared by the reaction of silver and hot and dil. HNO_3. This is a white crystalline substance whose m.p. is 214°C. This is extremely soluble in water. This is used as a laboratory reagent, in making hair dyes, in electroplating of silver compounds, in making special ink which is used by washerman in cloths marking and as a voter-marker on the finger of the hand. This is kept inside the coloured bottle because it decomposes.

To eat egg by a silver spoon is dangerous because silver directly reacts with sulphur of the egg and forms a black coloured silver sulphide (Ag_2S) compound which damages the spoon.

Gold

Symbol— Au, Atomic Number— 79, Mass Number— 197,

The place in the periodic table— I B, period— 6th

Element (Au)— *d*-block (coinage metal)

Electronic Structure—

$1s^2\ 2s^2 2p^6\ 3s^2 3p^6 3d^{10}\ 4s^2 4p^6 4d^{10} 4f^{14}\ 5s^2 5p^6 5d^{10}\ 6s^1$.

Occurrence and extraction of gold : It occurs as a metal in nature as well as in the forms of ores. Some important ores of the gold are calaverite ($AuTe_2$), sylvanite [(Ag . Au) . Te] etc. Gold is also recovered from auriferous quartz and from alluvial auriferous sands. This is extracted from auriferous sand by an amalgamation process.

Physical and Chemical properties of gold : This is a golden yellowish solid substance insoluble in the acid like HCl, HNO_3, H_2SO_4 etc but soluble in aquaregia and NaCN solution. It is the most malleable metal, ductile and good conductor of heat and electricity. This is a heavy metal whose m.p. and b.p. and specific density are 1064°C, 2610°C and 19.7 respectively. Gold can be made extremely hard if some copper is mixed up in it.

It doesn't react with air but dissolves in sodium cyanide (NaCN) and potassium cyanide (KCN) and sodium aurocyanide and potassium aurocyanide are formed.

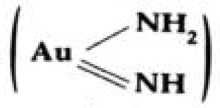
Uses of gold : This is used in making ornaments, coins, salt photograph of gold, in electroplating, in sugar industries. Thin layers of the gold are used in pharmaceutical industries.

Purity of gold : The purity of gold is expressed in carats. The gold which is completely (absolutely) pure is that of 24 carats but this doesn't exist because it is brittle. Thus copper is to be mixed up in very small amount. Normally gold of 23 carats or 22 carats is assumed to be pure in which 1 or 2 part copper is intermixed.

Compounds of gold :

1. Auric chloride ($AuCl_3$) : This is a brownish yellow crystalline solid moderately soluble in water which forms a golden yellow solution. It is used in making antidote of snake poisoning, in preparation of gold fulminate, purple of cassius, colloidal gold etc.

Fulminating gold



$$\left(Au \begin{smallmatrix} \diagup NH_2 \\ \diagdown\!\!\diagdown NH \end{smallmatrix}\right)$$

This is a green powder insoluble in water and on heating it explodes violently. That's why it is called fulminating gold. Thus it is used as a detonator.

Purple of Cassius [$Au + Sn(OH)_2$] : This is a purple powder, insoluble in water. The precipitated (*ppt.*) [$Au + Sn(OH)_4$] is purple in colour and ultimately it is filtered and dried in air. It is used in colouring the costly potteries with purple colour and also used in making ruby glass.

2. Rold gold [*Cu* (90%), *Al* (10%)] : This is called artificial form of gold which resembles like gold and it is used in making cheap ornaments.

In the electroplating process of gold, potassium aurocyanide is used as an electrolyte.

Iron pyrites is called fools gold.

Platinum

Symbol— Pt, Atomic Number— 78, Mass Number— 195,

The place in the periodic table— VIII, period— 6th.

Element (Pt)— *d*-block (Nobel metal)

Electronic Structure—

$1s^2\, 2s^2\, 2p^6\;\; 3s^2\, 3p^6\, 3d^{10}\;\; 4s^2\, 4p^6\, 4d^{10}\, 4f^{14}\;\; 5s^2\, 5p^6\, 5d^9\;\; 6s^1$.

Platinum is a transition element of the periodic table and it is also called white gold. This metal is a member of noble metals—silver, gold and platinum. It is also called Adam's catalyst. This is usually mixed up with nickel and copper ores. It doesn't react with air and doesn't dissolve in *HCl* etc.

Uses of Platinum : This is used in making ornaments, laboratory equipments and devices, electrodes, alloys and as a catalyst in Oswald's process. The tip of the nozel of the pen is also made from it.

Zinc

Symbol— Zn, Atomic Number— 30, Mass Number— 65.

The place in the periodic table— II B, period— 4th.

Element (Zn)— *d*-block (volatile metal)

Electronic Structure— $1s^2\ 2s^2p^6\ 3s^2p^6d^{10}\ 4s^2$.

Occurrence and extraction of zinc : This metal doesn't occur in fre state in nature but abundantly occurs in the forms of ores like zinc blende (ZnS), zincite (ZnO), calamine ($ZnCO_3$) etc.

Almost all zinc is extracted from zinc blende (*ZnS*) by carbon-reduction process.

Physical and Chemical properties of zinc : This is a bluish white, hard and brittle metallic substance. The m.p., b.p. and specific density of the zinc are 419°C, 920°C and 7.1 respectively. At a normal temperature it is neither malleable nor ductile. It is a good conductor of heat and electricity.

This reacts with dil. HCl and H_2 gas is emerged, but with dil. H_2SO_4 SO_2 gas is formed. It reacts with cold and dil. HNO_3 and forms NO_2 gas. When zinc is heated with conc. NaOH or conc KOH, H_2 gas is liberated and zincate is formed. Also in the solution of $CuSO_4$ it precipitated copper.

Uses of Zinc : This is used in the laboratory in the preparation of H_2 gas, it is also used in the galvanization of iron sheets to protect iron from rusting. buckets, boxes, many household articles are made from these sheets. Zinc is also used in making alloys like brass, bronze, German silver coins etc. This is also used in the extraction of gold, in production of smoke screen in battlefields.

Compounds of Zinc :

1. Zinc sulphate ($ZnSO_4$) : The hydrated zinc sulphate ($ZnSO_4 \cdot 7H_2O$) is called white vitriol. It is a colourless crystalline solid soluble in water.

This is used in textile industry for soaking cotton threads before spinning, in making preserver of wood and hides, in manufacturing of lithopone white pigment, in Calico printing and dyes industries.

2. Zinc oxide (ZnO) : This is an amphotaric oxide which is also called philosopher's wool. It exists in nature in the form of zincite or as an ore of zinc. This is a white incrystalline powder insoluble in water. It is used in making face-cream, white cream, artificial teeth etc due to these uses it is also called chinese white or zinc white.

3. Lithopone ($ZnS + BaSO_4$) : The mixture of zinc sulphide (ZnS) and barium sulphate ($BaSO_4$) is called Lithopone. This is obtained by the reaction of $ZnSO_4$ and barium sulphide (BaS). Lithopone is a white pigment which is used in preparing the white paint which doesn't turn black because atmospheric H_2S has no action on it.

4. Zinc sulphide (ZnS) : This occurs in nature in the form of zinc blende. It is a white solid which is insoluble in water. This exhibits the virtue of phosphorescence and that's why it is used in making phosphorescent screens.

5. Zinc phosphide (ZnP) : This is used as a rat poison.

Anhydrated ZnCl$_2$ is [illegible] wooden furnitures from electroplating of [illegible] germs or insects.

7. **Zinc carbonate (ZnCO$_3$) :** This is an incrystalline white solid which is insoluble in water. On heating it CO$_2$ gas is emerged out. This is used in making medicines of skin diseases.

Mercury

Symbol— Hg, Atomic Number— 80, Mass Number— 200.

The place in the periodic table— II B, period— 6th

Element (Hg)— *d*-block (volatile metal)

Electronic Structure—

$1s^2\ 2s^2 2p^6\ 3s^2 3p^6 3d^{10}\ 4s^2 4p^6 4d^{10} 4f^{14}\ 5s^2 5p^6 5d^{10}\ 6s^2$.

Occurrence and extraction of mercury : Mercury is not found abundantly in free state but it occurs in the form of ores. The main ore of the mercury is cinabar (HgS) and it is extracted by carbon reduction process from the cinabar.

Physical and Chemical properties of mercury : Mercury is a white shining metal like silver which occurs in the liquid state at an ordinary temperature. This is a good conductor of heat and electricity which is a monoatomic. If it is mixed up with fats or sugar and on strong mobilisation a brown colour powder is formed which is called deadening of mercury. It is neither malleable nor ductile and at 4.12 K the electrical resistance of it is completely vanished and it becomes a superconductor.

It doesn't react with water and alkali but it combines easily with metals and form amalgam. It reacts with chlorine and sulphur and in both cases mercuric chloride (HgCl$_2$) is formed. It reacts with cold and dil. HNO$_3$ and forms mercurous nitrate [Hg$_2$(NO$_3$)$_2$] and *NO*. But with hot and conc. HNO$_3$ it forms mercuric nitrate, NO and NO$_2$. It also dissolves in aquaragia and forms mercuric chloride.

Uses of mercury : Mercury is a very useful liquid metal used in making mercury thermometer, barometer, used as a contact liquid in electrical connection, in preparing amalgums, extraction of Au and Ag, in the industrial preparation of vermillian.

Compounds of mercury :

1. **Mercurous chloride (Hg$_2$Cl$_2$) :** This is also called calomel. It is a white crystalline powder which is insoluble in water and dil. acids. On heating with aquaragia it forms mercuric chloride (HgCl$_2$). This is used in the production of drugs in the form of bed-pills in making calomel electrodes etc.

2. **Mercuric chloride (HgCl$_2$) :** This is also called corrosive sublimate which is a deadly poison. This is a colourless crystalline solid which is moderately soluble in cold water but extremely soluble in hot water. If the solution of HgCl$_2$ is mixed up with NaOH then Nessler's Reagent (K$_2$HgI$_4$) is obt[illegible] ammonia (NH

This is used as a germicide in washing surgical instruments (equipm
before surgical operation.

3. Mercuric sulphide (HgS) : This is also called vermillion which i
red colour solid crystalline substance. It is insoluble in water and acid. Bu
it dissolves easily in aquaragia and forms mercuric chloride ($HgCl_2$). Th
is used in making medicines, in preparing water colours etc.

Miscellaneous

The composition of metals in which one metal is mercury (Hg) is called an amalgam, while the normal composition of metals are called alloys.

The metal mercury is kept inside an iron pot (container) because it doesn't form amalgam with iron.

Usually in tube light mercury vapour and argon gas are filled up.

The immediate rise and fall of reading in a barometer is the indication of clear weather and the prediction of the occurrence of a cyclone.

Metal mercury (Hg) is also called quick silver.

Lead

Symbol— Pb, Atomic Number— 82, Mass Number— 207.

The place in the periodic table— IV A , period— 6th.

Element (Pb)— *b*-block.

Electronic Structure—

$1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^{10}, 4s^2 4p^6 4d^{10} 4f^{14}, 5s^2 5p^6 5d^{10}, 6s^2 6p^2$.

Occurrence and extraction of lead : Lead occurs in nature mainly in the form of its ores. There are various ores of it exist in nature like galena (PbS), cerussite ($PbCO_3$), anglesite ($PbSO_4$) etc. The main ore is galena (PbS) from which lead is extracted by a self-reduction process. Lead is the most stable element among all the elements.

Physical and Chemical properties of lead : Lead is a soft bluish grey metal with a bright lustre and it is used as a paper marker. It is a heavy metal having density of 11.34, while its m.p. and b.p. are 327°C and 1620°C. It is a good conductor of heat and electricity and it is an amphoteric metal.

It doesn't react with dry air but reacts with moist air and forms the layer of hydroxide first and then of carbonate. When it is heated in the presence of air then lead oxide and red lead are obtained. It directly reacts with water and form its hydroxide, while with dil. HCl it forms H_2 gas. It also reacts with conc H_2SO_4 in which SO_2 gas is emerged out. When it reacts with dil. HNO_3 then nitric oxide is formed while with conc. HNO_3, NO_2 gas is formed in the form of a brownish smoke.

Uses of lead : Lead is a very useful metal and it is used in making alloys, lead accumulators, lead shots (bullet) and coverings of electric cables, lead chambers, lead pipes, lead-arsenic bullets, in nuclear research etc.

Compounds of lead :

1. Lead Oxide (PbO) : This is a volatile yellowish compound which is called Litharge. It is an amphoteric oxide and it is used in rubber industry, in the manufacture of flint glasses and storage batteries.

2. **Lead dioxide (PbO$_2$** coloured insoluble powder and it is used in Match Industry for making ignition surface of match boxes, used for preparation of $KMnO_4$.

3. **Tri plumbic tetraoxide (Pb_3O_4) :** This is also called Red lead and it is used in making red paint, flint glass, red lead element etc.

4. **Lead acetate [Pb (CH_3COO)$_2$] :** This is also called *SUGAR OF LEAD* and it is a white crystalline sugar like substance soluble in water and its crystals are sweet in taste. This is also called Inorganic sugar. This is used as a laboratory reagent in order to examine chlorides, sulphides and sulphate radicals. Lead acetate paper is used to examine the presence of H_2S, as a mordant etc.

5. **Lead carbonate ($PbCO_3$) :** This is also called white lead due to its white colour and it is insoluble in water but soluble in HCl and HNO_3. It is basically used in making white pigment.

6. **Lead tetra ethyl [Pb (C_2H_5)$_4$] :** It is a colourless mobile liquid having a special smell soluble in petrol. This is used as Antiknock Agent. When a very small quantity of it is added to the petrol knocking given by petrol in internal combustion engines is suppressed. Petrol mixed up with lead tetra ethyl is red coloured with an organic dye to distinguish it as a motor fuel.

Alloys of lead :

Alloys	**Compositions**
Type metal	Pb (75%), Sb (20%) and Sn (6%)
Solder	Sn (50-70%) and Pb (50-30%)
Pewter	Sn (75%) and Pb (25%)

Miscellaneous

The fuse wires which are used in the domestic electrical circuits and the appliances are made from alloys of lead (Pb) and tin (Sn).

The Jaber mines of Rajasthan is famous for its lead-zinc mining workshops.

The pipes of lead through which drinking water flows is not appropriate because lead reacts with water and forms poisoness lead hydroxide [Pb $(OH)_2$].

The element lead is an end element because every naturally occurring radioactive element transforms itself from a unstable to a stable element and stablises on the lead.

Thorium

Symbol— Th, Atomic Number— 90, Mass Number— 232,

The place in the periodic table— IV B, period— 7th.

Element (Th) f-block (radioactive)

Occurrence and extraction of thorium : This is a radioactive elem (metal) doesn't occur in free state but occurs naturally and abundantly in the ore of monozite sand near the sea shore. Thorium is mainly extracted from monozite ore.

Physical and Chemical properties of thorium : This is a brownish colour, metallic substance whose m.p. and b.p. are 145°C and 2800°C. The crystals of thorium are octahedral and its relative density is 11.23.

Uses of thorium : Thorium is used in the production of nuclear energy, as a glow tube electrode, x-ray target, as a tungsten filament of arc lamp, in the production of incandescent gas mantle, as a catalyst in the organic chemistry etc.

Uranium

Symbol— U, Atomic Number— 92, Mass Number— 238,

The place in the periodic table— III B, period— 7th.

Element (U)— *f*-block (radioactive)

Electronic Structure—

$1s^2\ 2s^2 2p^6\ 3s^2 3p^6 3d^{10}\ 4s^2 4p^6 4d^{10} 4f^{14}\ 5s^2 5p^6 5d^{10} 5f^3\ 6s^2 6p^6 6d^1\ 7s^2$.

Occurrence and extraction of uranium : It is a rarely found element in nature and it doesn't occur in free state. Almost all minerals of it are radioactive. The main ore of uranium is pitch blende from which it is extracted.

Physical properties of uranium : This is a lustrous white metal and it is malleable and too ductile but an impure brittle metal. This is the most radioactive element which occurs naturally. This is a paramagnetic and which relative density, m.p. and b.p. are 19.05, 1850°C and 3500°C respectively. Uranium is also called *Metal of hope*.

Uses of uranium : Uranium carbide is used as a catalyst in the production of ammonia (NH_3) by Haber's process. Uranium is used in the production of nuclear energy, it is used in the production of alloys, as a electrode in gas discharge tube, nitrate, chloride etc. of uranium are used in drugs manufacturing industries, nitrate and acetate of uranium are used in photography etc.

Isotopes of Uranium : There are three isotopes of uranium - ${}_{92}U^{234}$, ${}_{92}U^{235}$ and ${}_{92}U^{238}$. The most abundantly occurring uranium in nature is ${}_{92}U^{238}$ (99.28%) while ${}_{92}U^{235}$ (0.71%) and ${}_{92}U^{234}$ (0.006%) occur in very small amount. The isotope ${}_{92}U^{235}$ is used in nuclear (atomic) reactor as a nuclear fuel.

Plutonium

Symbol— Pu, Atomic Number— 94, Mass Number— 244.

Electronic Structure—$1s^2,\ 2s^2 2p^6,\ 3s^2 3p^6 3d^{10},\ 4s^2 4p^6 4d^{10} 4f^{14},\ 5s^2 5p^6$ $5d^{10} 5f^6,\ 6s^2 6p^6 6d^1,\ 7s^2$.

Plutonium is a heavy radioactive element (metal) which is the most active member of Actinium radioactive series. This is infact not a naturally occurring element but forms artificially and specially used in the nuclear fission bomb. In almost all nuclear (atomic) reactors of the world about 20 ton plutonium is used. Two cities of Japan—Hiroshima and Nagasaki during second world war were completely destroyed through the bombing of nuclear fission bombs (atom bombs) and in these bombs plutoniums were used.

Miscellaneous facts related to metals :

- Symbol of tungsten is W and its m.p. is 3500°C.
- Tungsten is produced from Degana mines of Rajasthan.
- The filament of an electric bulb is made of tungsten and the bulb is evacuated (vacuumed) to prevent the filament from burning and for a longer life span of the bulb.
- Bedilaite is an ore of Zirchonium.
- The metal zirchonium burns in both oxygen and nitrogen.
- Zirchonium has a neutron absorbing characteristic and that's why it is used in atomic reactor.
- Baryl is a main ore of metal berilium.
- Francium is a radioactive liquid metal.
- Stanus sulphide (SnS_2) is called Mosaic Gold and it is used in the form of paint.
- Tin is the best allotropic demonstrator.
- The heaviest metal among all is Osmium.
- Barium hydroxide is also called Baraita water.
- Barium sulphate is used as a barium indicative code in the human stomach during its X-ray test.
- In fire-cracking, the appearance of green colour is due to the presence of barium.
- In fire-cracking the appearance of crimson red colour is due to the presence of Stranssium.
- Litheum is the lightest metallic element and it is the strongest reducing agent.
- Metals like silver (Ag), gold (Au), copper (Cu), platinum (Pt) etc. occur in free states because of their lesser reactivities.
- Gold, Platinum, Silver and Mercury are called noble metals.
- The metals gold (Au) and silver (Ag) are two most malleable substances.
- Mercury and iron are two metals which produce greater electrical resistance with compare to others on passing the electric current.
- Silver and Copper are the best metalic conductors of heat and electricity.
  (Ag > Cu > Al) → (conductivity priority)
- The nature of the oxides of metals are basic (alkaline).
- The special smell in onion and garlic is due to the presence of potassium.
- The chemical name of cornotite is potassium uranil bendet.
- The isotope of cobalt is used in the treatment of cancer.
- Smeltite is an ore of Nickel (Ni)
- Nickel is used as a catalyst in the hydrogenation process of vegetable oils.

ator and in making alloys of low m.p. used in electric fuse … tor in atomic reactor, in ba

- The base of Afil tower which is of the world fame is constructed fr the steel and cement.
- The symbol of Thulium is Tm.
- Radium is extracted from pitch blende and it was firstly extracte Madam Curie.
- Metal Pledium is used in the manufacturing of aircrafts.
- Metal Galleium exists in liquid state at ordinary temperature.
- Metal Celenium is used in the manufacturing of photoelectric cell
- Iron is present in Cytochrome.
- Zeolite is used in softning drinking water.
- Almost all transition elements and their compounds are colou
- Potassium carbonate (K_2CO_3) is also called Pearl Ash.
- Nichrome is an alloy of Nickel, Chromium and Iron. The co electric heater is made of nichrome.
- The chemical name of chromic acid is chromium trioxide.
- Metal Britannia is an alloy of antimony, copper and tin.
- The moderate explosive is a mixture of potassium nitrate (75%), sulph (10%) and charcoal (15%) etc.
- Metal Babbitt is an alloy of tin (89%), antimony (9%) and copper (2
- The elements of group-I are called alkali metals and their hydroxides ar basic, while the elements of group-II are called alkaline earth metals
- Titenium is called a strategic metal, because it is used in defence. It stronger like steel but in weight it is light and half of the steel

Non-Metals

The elements which do not exhibit the metallic character are calle non-metals. In the periodic table almost all non-metals are kept toward the right. In modern periodic table there are 22 non-metals in which ther are 11 gases, 1 liquid and 10 solids. Bromine occurs in the state of liqui while hydrogen, nitrogen, oxygen, chlorine etc. are gaseous non-metals. B carbon, sulphur, phosphorus, iodine etc. are solid non-metals.

Hydrogen

Symbol— H, Atomic Number— 1, Mass Number— 1.

The place in the periodic table— I A, period— 1st

Element (*H*)— *s*-block (First and lightest among all elements)

Occurrence and preparation of H_2 : It has ninth position in the elemen which are found on the earth's surface. Upto some extent it looks like halog and that's why in the periodic table it has been kept is subgroup VII A w halogen. The basic constituents of the sun and star are hydrogen. Hydrog is called the fuel of future. This is the only element in the atom of which exists. Hydrogen was invente

Occlusion of hydrogen : When hydrogen gas is exposed on the powder of metal pladium then H_2 gas is absorbed completely and on heating these powder H_2 gas is released or occlusated which is called occlusion of hydrogen.

Hydrogenation of oil : At a high pressure in the presence of catalyst kel if hydrogen reacts with a vegetable oil and transforms it in a vegetable ghee) then this process is called hydrogenation of oil.

Uses of hydrogen : This is used as a fuel (liquid hydrogen) in the rocket, in the production of ammonia (NH_3) by Haber's process, in the manufacturing of vegetable ghee, in the production of Gasolene, in filling the balloons etc.

Today H_2 gas is not used in filling the balloons because it is slightly volatile and so a mixture of Helium-hydrogen (He - 85% + H_2 - 15%) is used. In aeroplane Helium gas is used in filling its tiers.

Various forms of hydrogen :

Nascent hydrogen : In the process of chemical reaction a suddenly emerged hydrogen gas is called nascent hydrogen. This hydrogen is more reactive than molecular hydrogen.

Atomic hydrogen : The hydrogen obtained by the decomposition of molecular hydrogen is called atomic hydrogen.

Ortho hydrogen : The form of hydrogen in which nuclei of the atoms of the molecular hydrogen revolve in the same direction is called ortho hydrogen.

Para hydrogen : The form of hydrogen in which nuclei of the atoms of the molecular hydrogen revolve in the opposite direction is called para hydrogen.

Isotopes of hydrogen : There are three isotopes of hydrogen— protium ($_1H^1$), deutrium ($_1H^2$) and tritium ($_1H^3$).

1. Protium ($_1H^1$) : It has equal atomic number and mass number and it is equal to 1.

2. Deutrium ($_1H^2$) : This is called heavy hydrogen and it has atomic number = 1, mass number = 2. It was invented by Urey Brickwedde and Murphy in 1931. It is used in explaining the mechanism of organic reaction and as a bombarding particle of the nuclear reactions.

3. Tritium ($_1H^3$) : Tritium ($_1H^3$) is a rarely occuring isotope of hydrogen and it is a beta emitter and a radioactive substance. Atomic number and mass liquid. H_2O_2 is a rarely and in small amount existing substance in the nature. Most probably H_2O_2 is formed by an exposure of ultraviolet rays on the oxygen in the presence of water vapour. H_2O_2 is used as both an oxidising and a reducing agent and due to its oxidising property it has a bleaching action on the silk, wool, hair, soft objects etc. H_2O_2 is also used in glazing the old oil paintings and in exposing its original colour. This is also used as a germicide and a pain reliefer in wounds washing, tooth and ear washing. This is also used in examing the milk, wine etc. and also used as a fuel of rocket, submarines, etc because oxygen is obtained from it.

3. Ordinary water (H_2O) : This is a compound which pure form is neutral and its *pH* is 7. Pure water is a bad conductor of electricity but an acidic water is a good conductor of electricity. At 4°C the density of the water is maximum and its volume is minimum. The ordinary water transforms into ice at 0°C. The rainy water is the purest form of the water and 97% parts of the entire water are assumed to be confined in ocean surroundings, while the rest 3% is only assumed to be confined in the pure form. The conversion of water into the ice and into the water vapour are examples of physical changes.

Types of water

1. Hard water : Hard water is not good for drinking because its taste is not good and it is harmful for the health. In it chloride, sulphate and bicarbonate of calcium and magnesium salts are dissolved. Also washing soap doesn't produce leather with hard water.

2. Soft water : Soft water is good for drinking because its taste is good and it is not harmful for the health. Washing soap produces leather with soft water.

Hardness of water : The hardness of water is of two types :

1. Permanent hardness : The existence of the hardness of water due to the chloride and sulphate of the Calcium and Magnesium salts is called permanent hardness of water. The permanent hardness of water is removed by mixing sodium carbonate in it and sometimes it is also removed by boiling the hard water by the means of distillation. The main method to remove the permanent hardness is called permutit's method.

2. Temporary hardness : The existence of the hardness of water due to the bicarbonates of calcium and magnesium salts is called temporary hardness of water. The temporary hardness of water is removed by boiling it. If sodium carbonate is mixed up into the water and boiled then both permanent and temporary types of hardness can be removed.

Miscellaneous

Water is said to be a universal solvent because it has the ability to dissolve so many substances within itself. Also due to a larger value of the dielectric constant water is assumed to be the best solvent.

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Carbon

Symbol— *C*, Atomic Number— 6, Mass Number— 12.

The place in the periodic table— IV A, period— 2nd.

Elements (*C*)— *p*-block elements.

Electronic Structure— $1s^2\ 2s^2 2p^2$.

Occurrence of carbon : Carbon occurs in nature abundantly in both free and compounds forms. In free state it occurs as diamond, graphite and coke, while in compound forms it appears as metallic carbonate, bicarbonate, CO_2, hydrocarbon, protein, carbohydrate and other complex compounds. The number of compounds of carbon are more than 5 lakhs, while the number of compounds of other elements are nearly 50 thousands. Carbon is a unique element of its group which has a special characteristic to form *C–C* bond and it is called catenation property of carbon. There are various allotropes of carbon like diamond, graphite, coal etc whose chemical properties are same but physical properties are differents. Carbon exists in both crystalline and non-crystalline forms.

Allotropes`of carbon :

Diamond : It is a precious gem and hardest substance but chemically it is a crystalline (cubical) allotrope of carbon. Naturally it occurs in cemberlite stone. There are various types of diamond which are found all over the world by the name of Culinan (3032 carat), hopp (445 carat), kohinoor (186 carat), pit (136.2 carat) etc. Artificial diamond was firstly prepared by Moisson in 1893.

Pure diamond is transparent, colourless and chemically inactive. There are close links of C-atoms in it and consequently a great hardness and involvent of its valence electrons in bond formation occurs that's why it is a bad conductor of heat and electricity. Diamond is a deadly poisonous substance, transparent to X-rays and hence a pure diamond is distinguished from an artificial diamond which is not transparent to X-rays. Due to the presence of various impurities the colours of diamonds are different, some diamonds are black which is called Bort. Due to an optical phenomenon an extremely brighten characteristic in the but when it is heated

Isotopes of carbon : There are three usual isotopes of carbon— $_6C^{12}$, $_6C^{13}$ and $_6C^{14}$, in which $_6C^{14}$ is a radioactive isotope called radioisotope because it is a β-emmitor. The carbon isotope $_6C^{12}$ has an International standard of atomic weight which is expressed in a.m.u.

At present two more isotopes of carbon $_6C^{15}$ and $_6C^{16}$ have been discovered which exhibit the property of radioactivity like $_6C^{14}$.

Compounds of carbon

(i) Carbon Monoxide (CO) : This is a colourless, tasteless, deadly poisonous and slightly soluble in water which is equally weighted in air and volatile gas. It burns with a blue flame and it is produced and appears as a smoke of motor vehicles which is the main pollutant of the city area (region). The smoke of carbon monoxide is cancerous. This gas is basically mixed up with haemoglobin of the human blood and forms a red complex substance called carboxy haemoglobin and due to this substance the absorption and circulation ability of the oxygen of the blood is diminished. Thus the respiratory activities of the man or woman is disturbed and at certain occasion it is so fatal that it becomes the cause of death. Carbon monoxide directly reacts with chlorine in the presence of sunlight which forms phosgene (carbonyl chloride) which is a poisonous gas.

Uses of CO : In the preparation of phosgene (carbonyl chloride), methyl alcohol and sodium formate, as a reducing agent in metallurgy, in the preparation of pure metal nickel in the production of producer gas and water gas in the forms of fuel.

(ii) Carbon dioxide (CO_2) : In atmosphere it occurs in a very little amount (nearly 0.03%) and this gas appears as an outgoing gas in human inhalation (respiration). This gas is absorbs by the plants and used in the photosynthesis process. Green house effect mainly caused by CO_2 gas. CO_2 is in fact an acidic compound and it is released in the process of fermentation. When limestone ($CaCO_3$) is heated strongly with hydrochloric acid (HCl) then a milky white substance lime water is obtained and CO_2 gas is emerged. In the soda water and cold drinks CO_2 gas is filled up at higher pressures.

Solid carbon dioxide is called ***dry ice***. CO_2 gas is also used in fire extinguisher and in fire extinguishing devices in the form of an aqueous solution of sodium bicarbonate, dil. H_2SO_4 is mixed up which produces CO_2 gas. Solid carbon dioxide is also used in refrigeration and an aqueous solution of CO_2 forms carbonic acid (H_2CO_3). Since in night the process of photosynthesis is completely stopped and so plants liberate CO_2 gas that's why it is suggested not to sleep in night near the plant or tree.

Uses of CO_2 : It is used in the production of soda water, cold drinks, white lead, in the manufacturing of hard steel etc.

Miscellaneous

Water gas is a mixture of carbon monoxide and H_2 gas.

Producer gas is a mixture of carbon monoxide and N_2 gas.

The bullet proofs are made from poly carbonates.

Today carbon fiber is used in the manufacturing of aircrafts.

Silicon

Symbol— Si, Atomic Number— 14, Mass Number— 28.

The place in the periodic table— IV A

Electronic Structure— $1s^2\ 2s^2 2p^6\ 3s^2 3p^2$.

Occurrence and uses of silicon : Silicon occurs in nature abundantly in the form of sand and stone but never found in free state. This is a non-metallic element which also exhibits the characteristic of allotropy. The hydride of the silicon is called silone. On the earth's surface (crust) it is the second abundantly occurring element after oxygen and it is nearly 26%.

Pure silicon is used as a superconductor, in making computer chips, used in semiconductor devices, in making alloys, in making acid resistant steel or iron, in making polymer like silicon, in silica gel as a drying agent, in making silica garden etc.

Compounds of silicon

(i) Silicon carbide : This is an artificial diamond called *carborendum.*

(ii) Silica (SiO_2) : It is also called sand which exists most abundantly in solid state in the nature and it is frequently used in the production of glass, cement etc. The substance like Quartz is a crystalline form of SiO_2.

Nitrogen

Symbol— N, Atomic Number - 7, Mass Number - 14.

The place in the periodic table— VA

Element (N)— *p*-block (Typical element)

Electronic Structure— $1s^2\ 2s^2 2p^3$

Occurrence and uses of nitrogen : Nitrogen is the main component of the atmospheric air and in the form of compound it is also found as ammonia, ammonium compounds and in nitrate forms. There is no allotropes of nitrogen like carbon and according to the volume it is 78% in atmospheric air. Nitrogen is also present in the complex organic compounds, and it is the main component (46%) of urea. Plants and trees intake nitrogen in the form nitrates from the soil. Creatures obtain nitrogen from the plants in the form of protein. In laboratory nitrogen is prepared by heating a mixture solution of ammonium chloride and sodium nitrite at 700°C. The molecules of nitrogen are diatomic and non-polar.

In the production of ammonia and ammonium sulphate fertiliser nitrogen is used commercially. Nitrogen is also used in the electric bulbs and thermometer of measuring the high temperature. It is also used in the artificial pregnancy of cows for which the sperm of bull is kept in it.

Fixation of nitrogen : The process of transformation of atmospheric nitrogen by the bacteria in the roots of plants of useful nitrogenous compounds is called fixation of nitrogen. The fixation of nitrogen takes place both by naturally and artificially. Symbiotic bacteria namely rhizobium takes part in the nitrogen fixation process in the joints of the roots of the leguminous plants. The process of transformation of nitrogenous compounds into nitrogen is called denitrification. Such process is performed by certain bacteria called denitrifying bacteria. Also in the process of denitrification released nitrogen by its compounds directly goes to the atmosphere.

… of nitrogenous compounds. exists and decomposition is called nitrogen cycle. Artificially a nitrogen fixation or a compound fixation is done by Haber's process and Birkland Eyde process.

Miscellaneous

Calcium cyanide [$Ca(CN)_2$] is known as Nitroleum, which is used as a chemical fertiliser.

Nitrogen gas directly reacts with metal magnesium and forms magnesium nitride (Mg_3N_2).

If a burning ribbon is introduced inside a nitrogen containing jar then it extinguishes.

Almost all ammonium salts on decomposition produce ammonia which has some special distinguishing smell, due to which toilets, horse parking venue etc have bad smell because of ammonia to be found in urine.

Compounds of nitrogen

(i) Ammonia (NH_3) : Firstly in 1774 Pristley obtained the gas ammonia (NH_3) by a strong heating of ammonium chloride and lime and called it Alkaline Air. Later in 1785 Berthollent asserted that ammonia is a compound of nitrogen and hydrogen and it is a stable hydride of nitrogen. Ammonia is manufactured at industrial level by Habber's process in which iron oxide (Fe_2O_3) acts like a catalyst and some alumina (Al_2O_3) and potassium oxide (K_2O) are mixed up in it which are the growth promoter of the catalytic reaction. Ammonia is basically a colourless and a strong smelled gas like onion. The basic structure of ammonia is tetrahedral, while its shape is pyramidal. It easily reacts with copper sulphate ($CuSO_4$) and a complex bluish colour compound cupric ammonium sulphate [$Cu\ (NH)_3\ SO_4$] is formed. At high pressure when ammonia is heated with CO_2 a complex organic compound urea is formed.

Liquified ammonia is used in freezing ice in the refrigerators, ammonia is used in the production of ammonium salts and urea, in cleaning, in the production of nitric acid (HNO_3) by Oswald's process and in the production of sodium carbonate (Na_2CO_3) by Solvey's process, in the production of hydrogen etc.

Before opening the bottle of liquid ammonia it is kept inside the ice because the vapour pressure of the liquid ammonia is much more.

(ii) Ammonium chloride (NH_4Cl) or Salammoniac : This is a white coloured crystalline substance which is used in dry cells, as a cleaner before welding the metallic surfaces, as a reagent in the laboratory, in drugs manufacturing, in the electroplating of utensils etc.

(iii) Nitrous oxide (N_2O) : This is also called laughing gas. This compound (N_2O) was firstly invented by Pristley. When an electric discharge … in air then oxygen and nitrogen combines (reacts) and nitric oxide

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This gas (N_2O) is used as an anesthesia in surgical operations, dental surgery etc.

(iv) Nitric acid (HNO_3) : This is an oxidising agent and a strong acid alkaline in nature. There are three processes of the manufacturing of it on the industrial level – (i) Ostwald's process (ii) Birkeland Eyde's process (iii) Retort's process.

This is used as solvents for many metals, as a reagent of laboratory, in the purification of metals like silver, gold, in making paintings on copper, brass, bronze etc, in the manufacturing of explosives like dynamite, Tri Nitro Tuluene (*TNT*), Tri Nitro Phenol (*TNP*), Tri Nitro Benzene (*TNB*) etc.

(v) Aquaregia (Conc. HNO_3 + 3 Conc. HCl) : This is a mixture of one part conc. HNO_3 and three part conc. HCl by volume. In aquaregia noble metals silver, platinum and gold easily dissolve which do not dissolve in ordinary acids like H_2SO_4, HNO_3, HCl etc.

(vi) Nitrous acid (HNO_2) : This is a very unstable compound of nitrogen and so it is prepared according to the requirement. HNO_2 behaves like both as an oxidising agent as well as a reducing agent. The salts of nitrous acids are called nitrites.

Miscellaneous

A mixture of carbon disulphide and nitric oxide kept inside a solution of nitrous acid (HNO_2) is used in Flash photography.

Sodium nitrate ($NaNO_3$) is called chile salt pieter.

Calcium carbonate [$Ca(NO_3)_2$] is called Narvegion salt pieter.

Potassium nitrate (KNO_3) is called salt pieter.

Ammonium carbonate [$(NH_4)_2CO_3$] is called smelting salt.

Hydrazine (NH_2) is today used as a fuel of rockets and aircrafts.

The salt obtained by ammonium chloride and conc. Chlorostanic acid is complex and it is called pink salt.

Phosphorus

Symbol— *P*, Atomic Number— 15, Mass Number— 31.

The place in the periodic table— V A

Element (*P*)— *p*-block, valency— 3 and 5.

Electronic structure— $1s^2\ 2s^2 2p^6\ 3s^2 3p^3$.

Occurrence and extraction of phosphorus : Phosphorus is a very reactive non-metal and easily catches fire in air in nature and that's why it does not occur in free state. It is found in nature in the form of stable phosphate. Animal bones contain nearly 58% calcium phosphate, while it is found in small amount in blood and urine of the animals as well as in the plants. There are various ores of phosphorus existing in nature and a few of them are phosphorite [$Ca_3(PO_4)_2$], chloraphite [$Ca_3(PO_4)_2CaCl_2$], redonda phosphate ($AlPO_4$) etc.

Almost all phosphorus is today extracted from phosphorite ore by the means of modern electric furnace process and a very small amount of phosphorus is extracted from bone ash by the old process.

Allotropic forms of phosphorus : There are various allotropes of it like white or yellow phosphorus, red phosphorus, scarlet phosphorus, black phosphorus, violet phosphorus etc.

White or yellow phosphorus (P_4) : The phosphorus obtained from old and modern process is white phosphorus and it exists in nature as a P_4 molecule at an ordinary temperature which is a white transparent but a soft solid like wax. White phosphorus is poisonous and most reactive among all the allotropes of phosphorus. White phosphorus has garlic like smell and when it is kept in the light it turns yellow and thus it is also called yellow phosphorus. It catches fire at room temperature because its ignition temperature is 30°C and so it is kept inside the water. Also it dissolves in carbon disulphide (CS_2) but it doesn't dissolve in water. White phosphorus produces an yellowish green light when kept inside the dark and this phenomenon is called phosphorescence. This structure is a regular tetrahedron while its shape is a triangular pyramid.

The burning of white phosphorus is an example of self ignition. This phosphorus is used in making firecrackers, used in the production of fire bomb and smoke bomb of battle-fields.

Red phosphorus (P_2) : Red phosphorus is a red crystalline solid less reactive than white phosphorus and it doesn't dissolve in liquid carbon disulphide (CS_2). It doesn't catch fire in air at room temperature because of high ignition temperature (260°C). This phosphorus exists as P_2 in the molecular form at ordinary temperature and its shape is linear. Due to the different atomic configuration red phosphorus exhibits difference in the physical and chemical properties and the physical appearance. If white phosphorus is heated at 250°C then it is transformed into red phosphorus. But if red phosphorus is heated at 550°C in presence of gases like N_2, CO_2 etc then a vapour of it is obtained and if it is quickly condensed then white phosphorus is formed.

This phosphorus is frequently used in matches manufacturing. In the manufacturing of safety matches a mixture of red phosphorus and phosphorus disulphide (P_2S_3) is used with potassium chlorate, antimony sulphide and powder of the glass specially in the matches sticks of the point iginator.

Scarlet phosphorus : This is obtained by heating a solution of 10% white phosphorus in PB_3 for a longer time of about 10 hours. It is basically a deep red crystalline solid, non-poisonous, insoluble in carbondisulphide (CS_2) more reactive than red phosphorus and it doesn't burn in air at ordinary temperature.

Black phosphorus : This is obtained on heating white phosphorus at about 200°C under a very high pressure. It is a black solid substance insoluble in CS_2, good conductor of electricity and it is inactive like red phosphorus.

Violet phosphorus : This is obtained on heating white phosphorus at 530°C in a closed tube. It is a violet solid substance insoluble in CS_2, does not burn at ordinary temperature and it is a bad conductor of electricity.

Compounds

(i) Phosphine (PH$_3$) : Naturally (decomposition) of rotten plants and organic substances graved inside the earth's surface in moist condition. But in the laboratory it is prepared by heating the white phosphorus with NaOH solution in the presence of coal gas. It is a colourless volatile gas which burns in air providing a dazzling shiny light. The smell of phosphene gas (PH$_3$) is like the rotten fish and it is poisonous (toxic).

This is used in making Calcium phosphide which is utilised in installing Home's signal and in making marineship's indicator. Calcium phosphide is also used in making smoke screen of battle-fields. Calcium phosphide directly reacts with water and impure phosphene is produced which automatically burns and forms the condensed smoke of meta phosphoric acid.

(ii) Phosphorus pentoxide :

Empirical formula– P_2O_5.

Molecular formula– P_4O_{10}.

It is a white powder acidic substance which is called phosphoric acid anhydride. The molecular structure of it is a regular tetrahedral.

This is used in making phosphoric acid, SO_3 and N_2O_5 etc. It is also used as a dehydrating agent, in drying acidic gases etc.

Miscellaneous

Hypophosphite compound of phosphorous is used in manufacturing of inner body strength (power) promoting drugs.

Phospher bronze, an alloy of phosphorus is a useful substance through which a special type of container is made.

Due to the lack of phosphorus, plants and trees can not exhibit the phenomenon of photosynthesis and leaves loss their colour and become dry.

Aluminium phosphide is used as a food grains preserver.

Zinc phosphide is used as a rat poison.

Both phosphene (PH$_3$) and ammonia (NH$_3$) have the same molecular composition but their physical and chemical properties are quitely different.

Oxy-acids of phosphorus

Hypophosphoric Acid—$H_2P_2O_6$

Orthophosphoric Acid—H_3PO_4

Acid—H_3PO_3

Occurrence and preparation of oxygen gas : Oxygen gas was firstly invented by a Sweden based scientist Scheele in 1772. It is a colourless, odourless gas which is slightly heavier than atmospheric air. It reduces into a deep blue liquid on cooling, it doesn't burn itself but favours the process of combustion. It is a paramagnetic diatomic gaseous substance and it is 20.29% in atmospheric air. It is prepared in the laboratory by heating potassium chlorate ($KClO_3$) in the presence of a catalyst MnO_2 at 375°C. A mixture of helium and hydrogen gas is used in the artificial inhalation. There are three isotopes of oxygen— $_8O^{16}$, $_8O^{17}$ and $_8O^{18}$.

Miscellaneous

Ore forming elements of group VI A are called common elements or typical elements.

Among all elements of the periodic table, polonium is the element which has the maximum number (27) of isotopes.

Liquid oxygen is used as a fuel of rocket.

If all the vegetations of our earth be destroyed then all living beings would die in the absence of oxygen.

Almost all oxygen of the atmospheric air is assumed to be produced through the photosynthesis process of all the vegetations of the earth.

Ozone (O_3) : This is an allotrope of oxygen and exists in a triatomic form. The smell of ozone gas is like the rotten fish. The ozone layer filters ultraviolet rays of the incident sunlight and upto 25 km altitude from the sea level the concentration of ozone is maximum. Atmospheric ozone is formed by the action of ultra-violet light on oxygen of the air. Ozone gas exhibits the characteristics of both oxidising and reducing agents. Ozone directly reacts with a unsaturated organic compound ethyline and forms ozonides.

The ozone is used as a germicide, air and water purifiers, preserver and freshnor of the foodstuffs, in making artificial silk etc.

Miscellaneous

When ozone gas exposes on silver, it makes an extremely brighten silver black.

Ozonosphere protects the human beings specially white people from ultra violet radiation of the sunlight which is the promoter of the skin cancer.

At present about 30% ozone layer has been depleted.

The depletion of ozone layer takes place at a very low temperature (nearly – 80°C) and firstly the incident of depletion was identified and detected at the uppermost layer of northern hemisphere.

The ozone layer depleter gases are CFC, CO_2, Cl_2, Br_2, CH_4, NO etc.

Sulphur

Symbol— S, Atomic number— 16, Mass Number— 32, the place in the periodic table— VI A

Element— *p*-block

Electronic configuration— $1s^2\ 2s^2 2p^6\ 3s^2 3p^4$.

Occurrence and preparation of sulphur : This is found in both free and complex forms in nature tremendously and in earth's crust its existence is nearly 0.05%. In free state sulphur occurs in the volcanic regions like Italy and Sisly Islands, Japan etc all around the world. In compound forms sulphur is mainly found in sulphide and sulphate of metals. Also in nature it is found abundantly in onions, garlics, eggs, mustard oil etc. But it is prepared by Frasch's process and Sicilian's process in the laboratory.

In sulphur molecules 8 atoms combine to form a ring like structure and thus its molecular formula is S_8. Ordinary sulphur appears like light yellow, brittle crystalline solid substance which is insoluble in water but soluble in carbondisulphide. It is a bad conductor of heat and electricity. It reacts with metals and form metallic sulphides. Thus on heating iron filings with sulphur powder, ferrous sulphide (FeS) is obtained.

Allotropes of sulphur

1. **Crystalline allotropic forms :**
   (i) Rhombic or Octahedral or α-sulphur.
   (ii) Prismatic or Monoclinic or β-sulphur.
2. **Non-crystalline allotropic forms :**
   (i) Plastic sulphur (ii) White sulphur (iii) Milky sulphur

As a result of sublimation of the sulphur obtained powder of it is called flower of the sulphur.

Pungent odour in the onions is due to the presence of sulphurous compounds.

Rhombic or octahedral or α-sulphur is the most stable allotrope of the sulphur.

On boiling sulphur becomes plastic sulphur if it is kept inside a cold water.

The process of mixing sulphur into the natural rubber is called *Vulcanisation.*

Uses of sulphur : It is used today in Beauty parlours to provide a specific touch of hair style, sulphur is also used in the production of SO_2, H_2SO_4, CS_2 etc., in the manufacturing of matches, explosive etc. It is also used in making ointments of sulphur as a medicine of skin diseases, in the production of sulpha drugs, calcium and magnesium bisulphides are used as a bleaching agent. Sulphur is also used in dyes, colour industries, in destroying germs, insects and as a fungicide.

Compounds of sulphur

1. Sulphur dioxide (SO_2) : During volcanic eruption the main gas which releases is sulphur dioxide and it is a colourless, suffocating and a gas of bitter smell. This gas is heavier than air and it is a poisonous gas. An aqueous solution of it is called sulphurous acid (H_2SO_3). It is easily liquified like NH_3, CO_2 and thus it is used as a refregeration gas. This gas is also used as an antichlor. It exhibits the property of bleaching action but it is temporary. The structure of SO_2 is angular.

2. Sulphur trioxide (SO_3) : It dissolves in water quickly and forms sulphuric acid (H_2SO_4) that's why it is also called anhydrides of sulphuric acid. The molecule of it is asymmetrical.

3. Sulphurous acid (H_2SO_3) : It exhibits the characteristics of both oxidising and reducing agents. This acid also acts like a bleacher and its bleaching action is due to its reducing property.

4. Sulphuric acid (H_2SO_4) : It is called chemical king of all the acids and it is also known as oil of vitriol. On the industrial level H_2SO_4 is manufactured by two process— Contact process and Lead Chamber process. In the production of it by Contact process platinum, vanedium pentaoxide (V_2O_5), Fe_2O_3 etc. are used as a catalyst, while oxides of nitrogen are used as a catalyst in its production by Lead Chamber process. H_2SO_4 is used in storage cell and as a petroleum purifie. This is a powerful dehydrator and due to this property by pouring conc. H_2SO_4 on sugar, sugar is faded and this phenomenon is called dehydration of sugar. If pure H_2SO_4 is chemically decomposed then on anode Marshal's acid is obtained.

5. Oleum ($H_2S_2O_7$) : This is also called fuming sulphuric acid or pyro sulphuric acid. When conc. H_2SO_4 dissolves into sulphur trioxide gas then pyro sulphuric acid ($H_2S_2O_7$) is formed which is also called oleum.

6. Hydrogen sulphide (H_2S) : During volcanic eruption in small amount hydrogen sulphide gas is also released. This is basically a colourless gas which is poisonous (toxic) and its smell is like rotten eggs.

Halogen

Halogen is a word of Greek letter which literal meaning is salt producer. The elements of sub group VII A of the periodic table are called halogen. The members of halogen are Fluorine (F), Chlorine (Cl), Bromine (Br), Iodine (I) and Acetetin (At). Usually halogenous elements do not exist in free state because of their higher reactivities. The elements Fluorine and Chlorine exist in gaseous state, while Bromine and Iodine exist in solid state. All members of the halogen are coloured, because they absorb visible light.

Iodine exhibits a metalloidal character, that's why it has metallic lustre.

Fluorine is the most electro negative element among all the elements of the periodic table, that's why it is the most reactive element.

Chlorine

Symbol— Cl, Atomic Number— 17, Mass Number— 35.

The place in the periodic table— VII A

Element— *p*-block

Electronic configuration— $1s^2\ 2s^2p^6\ 3s^2p^5$.

Occurrence and existences of chlorine : It is a greenish yellow gas with irritating pungent smell and slightly soluble in water. This is a poisonous gas which directly affects the human organs like throat, nose, lungs etc. On industrial level this gas is manufactured by Belden's process, Deacon's process, Calmer solvent's process, Nelson's cell's process etc. This exhibits a werful bleaching action due to its oxidation properties and so it can easily move the colour of flowers by the bleaching action. During the bleaching tion nascent form of chlorine actually takes part in the chemical reaction. is gas directly reacts with lime and bleaching powder is formed.

Uses : The chemical substances like bleaching powder, chloroform c. are manufactured by the chlorine. It is also used as a drinking water urifier, as a germicide, in removing colours from the garments and cloths, whitening sugar etc. It is also used in the production of toxic gases like hosgene, mustered gas etc.

Bromine

Symbol— Br, Atomic Number— 35, Mass Number— 80.

The place in the periodic table— VII A

Element— *p*-block.

Electronic configuration— $1s^2\ 2s^2 2p^6\ 3s^2 3p^6 3d^{10}\ 4s^2 3p^5$.

Occurrence and existence of Bromine : Bromine was firstly discovered by Balard in 1826 and it is a reactive non-metal that's why it doesn't exist in free state. It occurs in nature in the forms of bromides of sodium, potassium, calcium and magnesium. It also occurs in sea water in a little amount (nearly 0.068%). The important ores of bromine are carnalite [$KCl . MgCl_2 . MgBr_2 . 6H_2O$], tachyrite [$CaCl_2 . 2MgCl_2 . MgBr_2 . 12H_2O$] etc. But almost all bromine is extracted from carnalite. At ordinary temperature it appears like a dark red brownish liquid. In India it occurs abundantly at Rann of Kutch in the form of brine.

Uses : In the production of salts of bromide, hypobromide, bromates etc. in making toxic and weeping gases, in the production of *AgBr* used in photography. It is also used as a reactant in organic chemistry, in the production of *KBr* which is used in the form of sleeping drugs and pain reliefer.

Iodine

Symbol— I, Atomic Number— 53

The place in the periodic table— VII A

Element— *p*-block.

Electronic configuration— $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^6\ 4d^{10}\ 5s^2\ 5p^5$.

Occurrence and existence of Iodine : Iodine was discovered from the ashes of sea-weeds by a French salt peter - boiler named Courtois in 1811. It doesn't occur in nature in free state but in the compound form it is found as iodine in sea-water and sea-weeds. Iodine is a non-metallic solid of bluish colour in which metallic lustre is found. In human body Iodine exists in the form of organic compound thyroxin in thyroid gland. Due to lack of Iodine in the human body thyroid glands are abruptly increased which causes the disease Goitre.

Uses : It is used as a tincture of iodine and iodoform in the form of antiseptic and analgesic. Iodex (compound of iodine) is used as an external application of pain reliever medicine of bone injuries. This is also used in the manufacturing of several dyes and drugs, also used in the preparation of photographic paper, film and plates. Iodine is also used as a stronger germicide (insecticide).

Miscellaneous

Bleaching powder is a light yellowish colour substance (powd smell (odour) as that of chlorine.

The mixture of iodine and ethyl alcohol is called tincture of iodin

The chief source of iodine is chile saltpeter in the nature in which iodate ($NaIO_3$) is its main component found in Chile (Latin Ameri

Iodine occurs abundantly in the laminaria sea-weeds and after dryi weeds in deep ditches, ashes of the weeds are obtained called kelp in 0.4% to 1.3% iodine is to be found.

The element astatine (At) is a radioactive element which is an ext temporary radioactive but it is the heaviest non-metallic solid.

For good marking (writing) on the glass substances hydrofluoric used.

Fluorine is used in making compounds like UF_6 and SF_6 which are used the production of Atomic energy and in peizo electricity.

U-chlorine is a mixture of chlorine dioxide (ClO_2) and chlorine.

During the bleaching action of chlorine, it is used in excess to the substance bleached and to remove (neutralise) the excessness of the chlorine another suitable substance is taken which is called Antichlor.

Dichloro difluoro methane is called freon which is used as a refrigerant

Hydrochloric acid (HCl) is also called Maratic acid.

Inert Gases

Helium (He), Neon (Ne), Argon (Ar), Krypton (Kr), Xenon (Xe) and Radon (Rn) have been placed in zero group of the modern long form of periodic table. These are called inert gases because they are chemically inactive. Although, they are now called Noble gases because some of them have been found to react with fluorine and form stable compounds and they are not completely inreactive. Except radon (Rn), the other inert gases are found in atmospheric air in the elemental form.

All inert gases have monoatomic molecules. Argon (Ar) was the first noble gas discovered by Lord Rayleigh and Prof. Ramsay in 1892 from air. Helium was discovered by Prof. Ramsay in 1894 when he obtained it by heating clevite which is a Uranium mineral. In 1898 Ramsay and his student Travers obtained krypton which produced the characteristic lines in the yellow and green region of the spectrum. Neon was obtained from the volatile part of liquid argon and xenon was obtained from less volatile part of liquid argon. The family of group O elements was completed by the discovery of radon (Rn) from radioactive disintegration of radium.

Helium (*He*) : This is a light non-volatile gas and it is the second largest element found in the universe. Helium is used in filling the tyres of the aircraft and due to its lightness with comparison to air it helps in uplifting the aircrafts to upward. To obtain the weather related informations or observations helium gas filled balloons are left in open sky and relevant predictions and calculations are made. The mixture of helium and oxygen is ly deep sea diver (sailor) on the behalf of air because at larger pressure um is less soluble than nitrogen. The mixture of helium and oxygen s used in artificial breathing specially to the patients suffering from a in hospitals. Liquid helium is used as a low temperature reagent in xperiments occurring at a low temperature.

Neon (Ne) : This gas is frequently used in fluorescent bulbs and in ing advertisement. This is also used in Neon lamp through which ic indication is given to the aircrafts pilot at the aerodrome or airport. t this light of the lamp extremely shines in the fog. Thus neon is today d frequently in discharge lamps and fluorescent bulbs which are used quently in the advertisement.

Argon (Ar): This is the most abundantly occurring gas in the atmosphere d it is used in filling the ordinary electric bulbs because in the presence this gas filaments of the bulb have a longer life and remain intact even ter the regular and longer use. This gas is also used in high temperature etallurgical operations and the processes involve behind it or in creating cuum (being evacuated) in the arch welding of the alloys.

Xenon (Xe) : This gas forms the maximum number of chemical compounds.

Redon (Rn) : This is a radioactive element. This element is used in *adiotheraphy* in the treatment of cancer.

Metalloid

The element which exhibits both metallic and non-metallic characteristics s called metalloid. In the periodic table the place and position of the metalloid s between the metals and non-metals. There are seven metalloids— Boron (B), Silicon (Si), Germenium (Ge), Arsenic (As), Antimony (Sb), Telerium (Te) and Polonium (Po).

The compound boric oxide (B_2O_3) of boron like boric acid is used like a medicine and also used in the laboratory in Borex Beed Test. Thus boron s used in the production of graphite, benzine and boric acid (H_3BO_3). The boric acid is also used in manufacturing of antiseptic medicines. This is today also used in glass industries, in examing the food-stuffs adultration.

Miscellaneous

The compound antimony sulphide (Sb_2S_3) is used in making matches sticks specially in the form of volatile substance which forms the nob of matches's sticks.

Germenium is a semiconductor which is used in solid state electronic devices like transistor, photo electric cell, solar cell, photo diode etc. In solar cell cesium is also being used frequently.

Polinium (Po) is the first manmade (artificial) element which has maximum number (27) of isotopes.

Galium arsenide (GaAs) is today used as a semiconductor which is the cheapest among all the semiconductors. Computer chips of GaAs have been designed and fabricated and at present such chips are frequently operationalised.

5. Most fundamentals of Inorganic Chemistry

Allotropy : The two or more than two forms of an elements is called allotropes, while the presence of element in more than one forms is called allotropy.

Elements	**Allotropes**
Carbon	diamond, graphite, wood charcoal, bone charcoal, blood charcoal etc.
Phosphorus	white or yellow phosphorus, red phosphorus, black violet phosphorus etc.
Oxygen	Oxygen and ozone
Sulphur	Rhombic sulphur, monoclinic sulphur, amorphous sulphur, plastic sulphur etc.

Phosphorescence : If a substance like calcium sulphide is kept open in sunlight then the optical radiations are absorbed by such a substance and even after removing sunlight source it also emits radiations then this phenomenon is called phosphorescence.

Fluorescence : If the visible light is absorbed by certain substances then their atomic electrons become excited and after sometimes, these electrons come back in their original state then different radiations of different wavelengths are obtained, then this phenomenon is called fluorescence.

Efflorescence : The salts like $Na_2SO_4.10H_2O$, $Na_2CO_3.10H_2O$, $CuSO_4.5H_2O$ etc. have excess crystals of water and when these are left in open air in the presence of sunlight then these water crystals vaporise and salts transform into crystal powder, this phenomenon is called efflorescence.

Sublimation : The process in which certain solid substances like benzoic acid, anthracin, camphor, anthaquibinon, ammonium chloride etc on heating directly transform themselves into gaseous state and when these are cooled down then come into their original states, this process is called sublimation.

Isotope : The element which has equal atomic number but different mass number is called isotope.

Examples : Hydrogen has three isotopes—protium ($_1H^1$), deutrium ($_1H^2$) and tritium ($_1H^3$).

Isobar : The element which has equal mass number but different atomic number is called Isobar.

Examples : Argon ($_{20}Ar^{40}$), Potassium ($_{19}K^{40}$) and Calcium ($_{20}Ca^{40}$) are isobars.

Activity series of metals : There is a general order of the sequences of metals in chemistry on the basis of their decreasing order of reactivities called activity series.

In the activity series the metals have been kept beyond hydrogen which easily replace hydrogen from dil. acids, while more reactive metals replace less reactive metals from their salt solution.

Elements	**Activities**
Potassium (K)	Most reactive
Sodium (Na)	↓ decreasing reactivity
Calcium (Ca)	
Magnesium (Mg)	
Aluminium (Al)	
Zinc (Zn)	
Iron (Fe)	
Lead (Pb)	
Hydrogen (H)	
Copper (Cu)	
Mercury (Hg)	
Silver (Ag)	
Gold (Au)	Least reactive

Corrosion : If the metallic surfaces are affected by moisture, water, air etc. then it is called corrosion of the metals. Metals like copper, iron etc. are easily involved in the activities of corrosion, while noble metals—Silver (Ag), Platinum (Pt), Gold (Au) do not participate in the activities of corrosion.

Malleability and Ductility : The most fundamental characteristics of metals in which by hammering the metals thick foils or sheet can be made from the metals and it is called malleability. Almost all metals except mercury exhibits the characteristic of malleability. Gold and Silver are the two best metals which have extremely high level of malleability.

The fundamental characteristics of metals through which thick wires can be drawn from the metals is called ductility of the metals. Gold and Silver are the two best ductile metals.

Physical and Chemical changes : The changes occur in the substance in which internal molecular composition of it do not change but its physical shape, size, physical states etc. changes, called physical changes of the substance. Thus no new substance is obtained in the respect of its intrinsic molecular configuration and the substances undergoing physical changes are inter convertible.

Examples : The freezing of water into ice, the solution of sugar in water, to stretch spring, formation of clouds, formation of water vapours etc.

The changes occur in the substance which deform the internal molecular composition and a specific characteristic is introduced in the substance is called chemical changes. Thus in it a totally new substance is obtained and its characteristic is quitely different from the original.

Examples : The burning of magnesium ribbon, wax or candle, formation of rusting, formation of curd from milk, to obtain electricity from water etc.

Galvanization : To protect the metals like iron, copper etc. from rusting and corrosion, the fused or molten zinc is chemically decomposed through an appropriate process in which a thin layer of zinc is laminated then it is called galvanization.

Atomicity : Number of atoms present in a molecule of an element or a compound is called atomicity.

Example : In one molecule of the sulphur there are 8 atoms, so its atomicity is 8.

Catalysis : The chemical substance due to the presence of which the rate of chemical reaction is either increased or decreased but which are not involved in the chemical reaction itself is called catalyst and the process is called catalysis. Firstly the incident of catalysis was observed by Berzileous in 1835 and he confirmed that the rate of reaction can be affected by the presence of a chemical substance.

Example : If $KClO_3$ is heated at an extremely high temperature, then the released oxygen gas emerges very slowly, but if in small amount some MnO_2 is mixed up then even at a moderate temperature oxygen gas is released fastly.

Types of catalysis :

There are two types of catalysis—

(i) Homogeneous catalysis

(ii) Heterogeneous catalysis

In homogeneous catalysis, catalyst and reactants are in same physical state, while in heterogeneous catalysis, both catalyst and reactants are in different physical states.

Types of catalyst :

There are various types of catalyst but usually there are four types which are important—

1. **Positive catalyst :** The catalyst which activates the rate of reaction is called a positive catalyst.

2. **Negative catalyst :** The catalyst which deactivates the rate of reaction is called a negative catalyst.

3. **Auto catalyst :** When the product of a chemical reaction acts like a catalyst for the same chemical reaction then it is called an auto catalyst.

4. **Induced catalyst :** When the product of a chemical reaction acts like a catalyst of another chemical reaction then it is called an induced catalyst.

The substance which diminishes (destroys) the catalytic ability of the catalyst in chemical reaction is called catalytic poison.

The substance which reduces the rate of chemical reaction but doesn't take part in chemical reaction itself and thus acts like a catalyst is called inhibitor.

Applications of catalyst

Catalyst	Uses
Finely divided iron	In production of ammonia by Haber's process.
Finely divided platinum	In production of sulphuric acid by Contact's process.

Catalyst	Uses
Oxide of nitrogen	In production of sulphuric acid by Lead-Chamber's process.
Nickel	In production of artificial ghee from the vegetation oils.
Hot alumina	In production of ether from alcohol.
Cupric chloride	In production of chlorine gas by Deacon's process.
Pepsin enzyme	In decomposition of protein into peptide in stomach.
Erepsin enzyme	In decomposition of proteins into amino acids in intestines.
Trypsin enzyme	In decomposition of proteins into amino acids in pancreas.
Tylin enzyme	In transformation of starch into glucose in human saliva.
Ximase enzyme	In transformation of ethyl alcohol from glucose.
Dystase enzyme	In transformation of maltose from starch.
Mycodrumi aciti	In production of vinegar from sugar beat.
Invertage enzyme	In production of glucose and fructose from sugarcane.
Lactic vasili	In production of lactic acid from milk.

Enzyme : The compressed (condensed) nitrogenous substance which is to be found in microbes or micro organisms in which the process of fermentation is only involved is called enzyme. This is present in the cells of every living being and it is directly respondent for various metabolic activities.

Enzymes are sometime also called bio chemical catalysts. Thus enzymes are condensed substances like protein and these act like a contact catalyst and activate a decomposition process in which a complex organic substance splits into simpler substances. The enzymes are very exclusive and they perform single activity at a time. The activities of enzymes are abruptly diminished (vanished) in the presence of a toxic substance at a high temperature. At ordinary temperature enzyme works optimally.

Man made substances : (A) Cement : Firstly cement was used by a U.K. scientist Joseph Aspdin in 1824 and he called it portland cement because this cement demonstrated the resemblance of lime sediments found at Portland. The cement is basically a mixture of calcium aluminate and calcium silicate which is a grey coloured powder. This has a specific characteristic to react with water and becomes rigid. In the cement lime, silica, alumina, magnesia, oxides of iron and sulphur etc are mixed up (composed). Whenever the cement comes in the contact of water then the silicate and aluminate of calcium react with it and form a colloidal solution which is soldified.

Due to the excess amount of lime in the cement it is cracked on soldification, while due to the excess amount of alumina it soldifies easily and quickly.

In the production of cement lime sediments and smooth clay are used as raw materials. The lime sediments provide calcium oxide (CaO) while smooth clay provides silica, alumina, ferric oxide.

Composition of cement : CaO (60-70)%, SiO_2 (20-25)%, Al_2O_3 (5-10)%, Fe_2O_3 (2-3)% etc.

Mortar and Concrete : If along with cement some sand (silica) is mixed up then this specific mixture is called mortar which is used in the building construction, bridge construction etc.

But if along with cement and sand some stone particles in small amount are mixed up then this mixture is called concrete which is the main component of the building construction.

Reinforced cement concrete : If concrete is strengthened by infusing frames of wires or of iron rods in the concrete for a specific construction purpose then it is called reinforced cement concrete. Such types of concretes are used in the construction of roofs of the houses, pillars, bridges, barrages etc.

B. Glass : Firstly the glass was manufactured in Egypt. Basically glass is a homogenous mixture of the silicates of various alkalined metals of non-crystallined and transparent or less transparent substances. Ordinary glass is manufactured by the composition of various substances like silica, bleaching powder, oxides of alkaline metals, calcium oxide (lime) etc. These constituents of the glass are transformed into a fine powder and after fusing these are melted into the furnaces at a moderate temperature and ordinary glass is prepared by a suitable cooling mechanism of the molten or liquid glass. Thus ordinary glass is a non-crystallined substance of a ultra cooled liquid glass.

Types of Glass

1. **Water glass :** This is basically a compound of sodium silicate (Na_2SiO_3) which is obtained by heating sodium carbonate and silica. The water glass is soluble in water.
2. **Photochromatic glass :** This is a special type of glass which turns black in sharp shining light thus such glasses are used as a light protector and eyes reliefer and thus used in making eye lenses and goggles. The main reason of being black of such glasses is the presence of silver iodide.
3. **Pyrex glass :** This is also called borosilicate glass. Pyrex glass has some specific characteristics of chemical durability and more thermal inmalleable resistance power.
4. **Lead crystal glass :** This is a special type of glass which is used in making various ornamental items by the appropriate decorative cutting and designing. Infact on cutting such glasses an optical phenomenon of total internal reflection takes place very strongly and thus a pleasures dazziling light is produced.
5. **Soda glass :** This is also called soft glass which is brittle and the cheapest and most common glass. This can be broken very conveniently and by the alternation of temperature some cracks appear in such glasses.

Jena glass : This is the best form of glass and from it chemical containers and equipments for the scientific purposes are manufactured. This glass is basically composed from zinc and barium borosilicate which produces the soft and good quality glass.

7. **Flint glass :** This is basically composed from sodium, potassium and lead silicates which is used in making idol objects of cultural importance, costly glass equipments or devices. Such glasses are also used in making electric bulbs, lenses of telescopes, microscopes, camera and prisms, etc.

8. **Crown glass :** Usually this is a soda-lime-silica glass and it is frequently used in making lenses of eye glasses.

9. **Crookes glass :** In this glass mainly sirium oxide (CiO_2) is present which strongly absorbs the ultraviolet rays from the sunlight and used in making lenses of eye glasses.

10. **Quartz glass :** This is also called silica glass because it is obtained by melting silica and ultraviolet rays emerge out through it. Thus it is used in making bulb of ultraviolet lamp, in making container of chemical reagents, laboratories equipments etc.

Miscellaneous

In making utensils fused (molten) glass is kept inside various designed frames and later it is cooled down, slowly, steadily and moderately. The involved process is called annealing of glass.

If a very small amount of cullet is mixed up in the glass then the glass melts very quickly and conveniently.

To make the glass hard potassium chloride (KCl) is mixed up.

There is neither any crystallined structure of the glass nor any definite melting point of it.

There is no definite chemical formula of glass because it is a mixture of the variable components.

Optical fibre (a good quality glass) is used in the telecommunication and endoscopy.

Main glasses, composition and their uses

Glasses	Composition	Uses
Soda glass	Sodium carbonate, calcium carbonate and silica.	In making tubelight, bottles, equipments of laboratory, daily usable domestic utensils.
Flint glass	Potassium carbonate, lead oxide and silica.	In making electric bulbs, lenses of camera and telescope etc.
Crooks glass	Serium oxide and silica.	In making lenses of goggles.

Glasses	**Composition**	**Uses**
Potash glass	Potassium carbonate, calcium carbonate and silica.	In making glass container and laboratory equipments, glass utensils which are heated up to a very high temperature.
Pyrex glass	Barium silicate and sodium silicate.	In making laboratory equipments and pharmaceutical containers (vessels).
Crown glass	Potassium oxide, barium oxide and silica.	In making lenses of eye's glass.
Lead crystal glass	Potassium carbonate, lead oxide and silica.	In making costly glass containers (vessels) etc.

Coloured glass and its chemistry : During the formation of glasses its various components (constituents) in the molten (fused) state are sometimes altered (replaced) or more appropriately some extraneous substances like metallic oxides are added in a very small amount then glasses become coloured. Also various added substances produce different colours in the glasses. For example— On adding ferric oxide in an ordinary fused glass a brown coloured glass is obtained. Similarly on mixing the substances like chromic oxide, manganese dioxide, cobalt oxide etc. in fused glass, green, red and blue coloured glasses are produced. Generally for the fascinating coloured glasses small quantity of metallic compounds are mixed up in the molten (fused) state with their components.

Colour supplying substances	**Colour of glasses**
Cobalt oxide	deep blue
Sodium chromate or Ferrous oxide	Green
Silenium oxide	Orange red
Ferric salt or sodium uranet	Fluorescent yellow
Gold chloride or purple of casias	Ruby red
Cuprrous oxide, cadmium sulphide	Glitter red
Cuprric salt	Peacock blue
Potassium dichromate	Green and green yellow
Manganese dioxide	Blue to light orange
Cuprrous salt	Red
Cadmium sulphide	Yellow like lemon
Carbon	Brownish black

C. Fertilizers : To maintain (balance) the fertility level in the soil some extraneous substances like manures and chemical compounds are used which are called fertilizers. Through optimum level of the growth of the crops and the nutrient components in the crops are to be promoted. Thus fertilizers are the chemical substances by the help of which the substantial growth of the plants (crops) are to be maintained and supply the nutrients in the form of nitrogen, phosphorus, potassium etc. which keep the soils fertile.

Classification of Fertilizers : The fertilizers are classified on the basis of the nature of nutrient elements like Nitrogen, phosphorus, potassium (*NPK*) present chemically in the compounds. There are various nitrogenous chemical fertlizers like ammonium sulphate, calcium ammonium nitrate, basic calcium nitrate, calcium cyanamide (nitrolium), urea etc. Obviously these fertilizers supply nitrogen to the soil. Similarly there are various phosphatic chemical fertilizers like super phosphate of lime, triple super phosphate etc and potash chemical fertilizers like potassium chloride, potassium nitrate, potassium sulphate etc. Thus phosphatic and potash chemical fertilizers supply phosphorus and potassium to the soil respectively.

There are also some chemical fertilizers of different composition like that of nitrogen phosphorus (NP) fertilizers in which nitrogenous and phosphatic fertilizers are mixed up in a suitable definite ratio. The fertilizers like dihydrogen ammoniated phosphate, calcium super phosphate etc. are *NP* fertilizers. Sometimes *NPK* fertilizers are composed to supply nitrogen, phosphorus and potassium all simultaneously to the soil.

Main chemical fertilizers :

Ammonium sulphate [$(NH_4)_2\ SO_4$] : This is a nitrogenous fertilizer which is used in raising the production level of crops like paddy, potato etc. In this fertilizer there is nearly 25% ammonia which is transformed into the nitrate by the deniterifying bacteria present in the alkaline soil. Thus these nitrates are easily absorbed by the crops (plants). This fertilizer is produced at large scale at Sindri of Jharkhand in India.

Calcium Ammonium Nitrate [$Ca(NO_3)_2\ NH_4NO_3$] : This is also a nitrogeneous fertilizer in which the amount of nitrogen is about 20% which is directly absorbed by the plants. On mixing it in the soil no adverse effect appears in the soil and due to the extreme solubility in water it is easily intermixed in the soil. This chemical fertilizer is manufactured at large scale at Nangal in Punjab.

Super Phosphate of lime [$Ca\ H_2\ (PO_4)_2 + CaSO_4\ .\ 2H_2O$] : This is a homogeneous mixture of calcium dihydrogen phosphate [$Ca\ H_2\ (PO_4)_2$] and Gypsom [$CaSO_4\ .\ 2H_2O$] in which 16-20% P_2O_5 exists. The reactive component of this fertilizer is calcium dihydrogen phosphate which is soluble in water. Another phosphatic fertilizer is triple super phosphate of lime which is also used on the behalf of super phosphate of lime and it is prepared by the powder of bones.

Urea (H_2NCONH_2) : This is obtained by heating the mixture of carbon dioxide at 125-150°C and at about 8.5 atmospheric pressure. In urea there is nearly 46% nitrogen and this fertilizer is used during introducing the seed into the soil but this fertilizer is never brought in the contact of the seed. After spreading urea on the soil, water is supplied 3-4 days later.

Calcium caynamide [$Ca\ (CN)_2$] : This is also called Nitrolim and it is basically a nitrogenous fertilizer which is supplied in the market as a mixture of [$Ca\ (CN)_2$] and carbon. This fertilizer is used before introducing seed into the soil but it is never used for the growth purposes of the crops.

Calcium nitrate [$Ca\ (NO_3)_2$] : This is a nitrogeneous fertilizer and in market or commercially it is called Narvegian salt peter.

III. Organic Chemistry

Primitively the term organic chemistry was used in anglo language and the word bio implied for organic. The chemical substances found in living beings were called organic substance in earlier time. But at present the modified concept about the organic chemistry which are internationally accepted by IUPAC on the basis of concensus is given as below ;

The branch of chemistry in which the chemical compounds of carbon are studied except carbon itself and carbonate, bicarbonate, metallic cyanamide, CO, CO_2 etc. are assumed to be inorganic compounds is called organic chemistry.

In ancient time a Sweden based chemist Berzileus asserted that organic substances have been composed from a great super power in nature and these substances can not be formed in laboratory. This concept of Berzileus was called *Vital Force Theory* but later researches discarded this concept.

In 1828 Wohler composed and invented a complex organic compound by the synthesis (heating) of a mixture of two inorganic compounds—ammonium sulphate and potassium cyanate, called Urea (NH_2CONH_2).

$$\underset{\text{Ammonium sulphate}}{(NH_4)_2SO_4} + \underset{\text{Potassium cyanate}}{2KCNO} \longrightarrow \underset{\text{Ammonium cyanate}}{2NH_4CNO} + \underset{\text{Potassium sulphate}}{K_2SO_4}.$$

$$\underset{\text{Ammonium cyanate}}{NH_4CNO} \longrightarrow \underset{\text{Urea}}{NH_2CONH_2}.$$

Later in 1844 Kolbe synthesised Acetic acid by carbon, hydrogen and oxygen, while Berthelot synthesized methane (CH_4) in 1856.

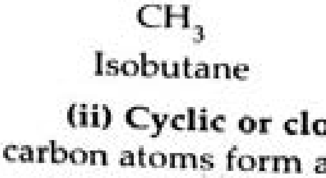
1. Classification of organic compounds : Organic compounds are broadly classified into two categories—

(i) Aliphatic or Open chain compounds : Organic compounds in which carbon atoms are attached in open chain are called aliphatic compounds. These compounds exist in such a way that carbon atoms are attached in branched or straight chains.

Examples : Normal butane, normal pentane are simple chain compounds;

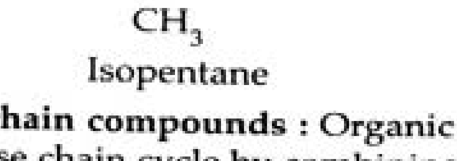
$$\underset{\text{Normal butane}}{CH_3-CH_2-CH_2-CH_3} \qquad \underset{\text{Normal pentane}}{CH_3-CH_2-CH_2-CH_2-CH_3}$$

Similarly isobutane, isopentane, Neopentane etc are branched chain compounds;



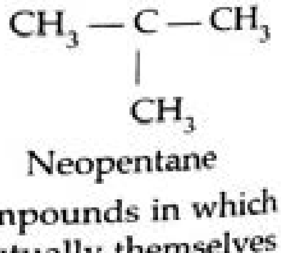
$$CH_3-\underset{\underset{CH_3}{|}}{CH}-CH_3$$

Isobutane



$$CH_3-\underset{\underset{CH_3}{|}}{CH}-CH_2-CH_3$$

Isopentane



$$CH_3-\overset{\overset{CH_3}{|}}{\underset{\underset{CH_3}{|}}{C}}-CH_3$$

Neopentane

(ii) Cyclic or close chain compounds : Organic compounds in which carbon atoms form a close chain cycle by combining mutually themselves

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are called cyclic compounds. On the basis of configuration of the chain or cycle it is further divided into two groups—

1. Carbocyclic or Homocyclic compounds : Those cyclic compounds which are composed from carbon atoms only are called carbocyclic or Homocyclic compounds. These carbon cyclic compounds may further be divided into two groups—

(a) Aromatic compounds : The word Aromatic is made from word Aroma which implies smell. The cyclic carbon compounds in which six carbon atoms form a closed chain are called aromatic compounds. The organic compounds like benzene, phenol, anilene etc. are examples of aromatic compounds.

(b) Alicyclic compounds : Some characteristics of cyclic compounds which have closed chains exhibit more resamblence to the aliphatic compounds than aromatic compounds, that's why such compounds are called alicyclic (aliphatic + cyclic) compounds.

In such compounds there are more hydrogen atoms than aromatic compounds. The organic compounds like cyclobuten, cyclopenten, cyclohexen etc. are examples of alicyclic compounds.

2. Heterocyclic compounds : The cyclic compounds in which closed chain is made from the elements other than carbon are called heterocyclic compounds. The organic compounds like piroll, fueran, thayophin, piredin etc. are examples of heterocyclic compounds in which nitrogen, oxygen, sulphur etc. are hetro atoms respectively.

Methane is called the father of the all aliphatic organic compounds.

Benzene is called the father of the all aromatic organic compounds.

Functional group : The group or radical present in an organic compound on which main properties of the compound depends is called functional group.

Example : Ethyl alcohol (C_2H_5OH) is made from two groups, ethyl ($-C_2H_5$) and hydroxil ($-OH$), but since the main properties of ethyl alcohol depend on – OH, so its functional group is – OH.

Main organic compounds and their functional groups

Organic compounds	Functional groups	Organic compounds	Functional groups
Alcohol	$-OH$	Chloro	$-Cl$
Ether	$-O-$	Cyano	$-CN$
Aldehyde	$-CHO$	Isocyano	$-NC$
Ketone	$>C=O$	Phenyle	$-C_6H_5$
Ester	$-COOR$	Vinyle	$-CH_2=CH$
Carbocyclic acid	$-COOH$	Acetyle	$-COCH_3$
Amine	$-NH_2$	Anelyde	$-NHCOR$
Anhydride	$RCOOCOR$	Benzoyle	$-COC_6H_5$
Nitro	$-NO_2$	Benzyle	$-CH_2C_6H_5$
Amide	$-CONH_2$	Oxym	$=NOH$
Alkyle	$-R$	Hydrazene	$=NNH_2$
		Mercaptan	$-SH$

2. Some important incidents of organic chemistry

A. Homologous series : The family or series of organic compounds in which every member has same functional group and similarities are found in chemical properties and structures among the members is called homologous series. Also in homologous series there is a difference of $-CH_2-$ between two adjacent members of the series and members of this series are called homologous. The phenomenon occurring is called homology.

The family of alkene and alcohol for example have homologous series— Methyl alcohol (CH_3OH), Ethyl alcohol (C_2H_5OH) Propyl alcohol (C_3H_7OH). Obviously there is a gap of $- CH_2 -$ group among every two adjacent members. There are so many examples of homologous series in organic chemistry but each have a difference of $- CH_2 -$ group in their two adjacent series members.

Characteristics of homologous series

1. All members of the homologous series are represented by a common general formula
   Examples : C_nH_{2n+1} OH, C_nH_{2n+1} CHO are the general formulae of alcoholic and aldehydic group of homologous series.
2. All members of a homologous series may be prepared by some common chemical reactions.
3. In a homologous series the molecular wts. of any two adjacent members have a difference of 12 amu.
4. In homologous series with increase of molecular wts. the physical properties like b.p., m.p., density etc of the corresponding members change.

B. Polymerisation : The chemical reaction through which two or more molecules of a compound form a larger molecule called polymer or polymerized compound and the process is called polymerisation. The process of polymerisation takes place under certain specific condition and so molecules of every compounds do not take part for polymerisation, in chemical reaction. The molecules (smaller) which are involved in the chemical reaction for polymerisation are called monomer while that of products (larger) are called polymer.

Example : If an acetylene gas is poured in a red hot copper pipe then three molecules of acetylene (C_2H_2) are polymerised and benzene (C_6H_6) is formed. Here acetylene is called monomer while benzene is called polymer.

Characteristics of polymerisation

1. Polymerisation is a reversible chemical process in which polymers easily and conversely decompose into monomers.
2. The molecular wt. of the polymer is the multiple factor of the molecular wt. of the monomer.
3. In polymerisation the identical molecules mutually combine to form polymer.
4. In polymerisation carbon atoms do not form any new type of bonds.
5. In polymerisation the smaller molecules of water etc do not release.

Some useful polymers and monomers

Polymer	**Monomer**	**Uses**
Polythene	Ethylene ($CH_2 = CH_2$)	In making poly bags, tube packing commodities.
Poly styrence	Styrene ($C_6H_5CH = CH_2$)	In making radio and television cabinet etc.
Poly propyle	Propylene ($CH_3CH = CH_2$)	In making tube.
Teflon	Tetra flour ethylene	In making non-sticky cooking utensils.
Poly Vinyle-Chloride (PVC)	Vinyle chloride ($CH_2 = CHCl$)	In making cable of dish-antenna.
Nylon	$H_2N(CH_2)_6NH_2$ and $HOOC(CH_2)_4COOH$	In garment industry.
Terylene	$HOCH_2CH_2OH$ and screening	In garment industry.

C. Fermentation : The term fermentation originated from Latin word *Fervere*, which implies boiling. The process of fermentation was not new for the ancient people in fact they were well known about such incident. But the scientific study of fermentation was firstly done by a French chemist Loius Pashcher.

The process of decomposition of complex organic compounds by micro-organisms or bacteria into simpler organic compounds is called fermentation. The process of fermentation simply occurs by the help of nitrogenous substance which acts like a catalyst and called ferment. The examples of fermentations are so many in our daily life—like to prepare wine and vinegar from the juice of sugarcane, to convert milk into the curd, occurring of sourness in the milk and intertwined flour. Thus the process of fermentation occurs in the presence of yeast or bacteria and this process is an exothermic reaction in which heat is released. Also during the process of fermentation various gases like CO_2, H_2, CH_4 etc. emerge simultaneously and the appearance of these gases seem like boiling the fermentive solution of the substance.

D. Isomerism : The organic compounds whose molecular formulae are same but atomic configurations of the molecules are different and their physical and chemical properties are different is called isomers and the phenomenon is called isomerism.

Example : Normal butane and isobutane have same molecular formula C_4H_{19} but their atomic arrangement in the molecules are different so their properties are different. Thus both are isomers to each other.

Types of isomerism

(i) Structural isomerism : This isomerism occurs due to the difference appearing in configurational (structural) arrangement of the atoms of the molecules of the organic compounds.

(ii) Stereo isomerism : This isomerism occurs due to the difference in electronic configuration of the atoms of the molecules of the organic compounds.

E. Cracking: The decomposition process of the molecules of hydrocarbon of larger molecular wt. into the hydrocarbon of smaller molecular wt. at a suitable temperature is called cracking. Usually larger molecules of saturated hydrocarbon decomposes on heating and form a saturated hydrocarbon of smaller molecules and unsaturated hydrocarbon of smaller molecules.

Example :

$$\underset{\text{Decane}}{C_{10}H_{12}} \xrightarrow[\text{cracking}]{\text{heating}} \underset{\text{Octane}}{C_8H_{18}} + \underset{\text{Ethylene}}{C_2H_4}$$

$$\underset{\text{Decane}}{C_{10}H_{22}} \xrightarrow[\text{cracking}]{\text{heating}} \underset{\text{Heptane}}{C_7H_{16}} + \underset{\text{Propene}}{C_3H_6}$$

Normally only about 20% petrol is obtained from petroleum, so a greater demand of petrol is today fulfilled by applying the cracking process on the hydrocarbons of higher boiling point.

3. Hydrocarbon

Organic compounds obtained from the simple combination of hydrogen and carbon are called hydrocarbons. The organic compounds like petrol, diesel, kerosene oil etc are the examples of natural products of the petroleum. Thus petroleum is a natural source of hydrocarbon. Hydrocarbon is usually divided into two categories—

1. Aliphatic hydrocarbon 2. Aromatic hydrocarbon

Open chain hydrocarbon is called aliphatic hydrocarbon, while closed chain hydrocarbon is closed aromatic hydrocarbon. Also aliphatic hydrocarbon is odourless, while aromatic hydrocarbon has a special type of smell (odour).

1. Aliphatic hydrocarbon : Aliphatic hydrocarbon may further be divided into two groups—

(a) Saturated hydrocarbon or Alkane or Paraffin.

(b) Unsaturated hydrocarbon.

(a) Saturated hydrocarbon : This is also called alkane or paraffin. Paraffin is a Latin word, which implies— less active and because of lesser activities of saturated hydrocarbons these are called paraffin. General formula of the member of the series of saturated hydrocarbons is given by C_nH_{2n+2}; where n is the number of member of the series. The organic compounds like methane, ethane, propane, butane, pentane etc. are saturated hydrocarbons in which all carbon atoms are attached with single covalent bond.

(b) Unsaturated hydrocarbon : Those compounds of aliphatic hydrocarbons in which carbon atoms have double or triple covalent bonds are called unsaturated hydrocarbons. This is also of two types;

Alkene or Olefin : Those compounds of unsaturated aliphatic hydrocarbon in which carbon atoms have double covalent bond are called Ethylinic hydrocarbons or oleffin or alkene. General formula for the members of this series is C_nH_{2n}. The organic compound Ethylene (C_2H_4) is an example of alkene.

Acetylenic hydrocarbon or alkynes : Those compounds of unsaturated aliphatic hydrocarbon in which carbon atoms have triple covalent bond is called acetylenic or alkynes. General formula for the members of this series is C_nH_{2n-2}. The organic compound acetylene (C_2H_2) or ethyne is the simplest example of this hydrocarbon.

2. Aromatic hydrocarbon : Those compounds of hydrocarbon which are composed from hydrogen and carbon and have the branches like benzene are called aromatic hydrocarbons. General formula of the members of this series is C_nH_{2n-6}. There are various compounds like benzene, toluene, napthalene, anthracene etc. are the examples of aromatic hydrocarbon in which benzene is the simplest one. Sometimes aromatic hydrocarbons are also called Arenes.

Simpler organic compounds of carbon, hydrogen and oxygen : There are various organic compounds of carbon, hydrogen and oxygen which are obtained by a definite composition and combination of various functional groups like alcohols, ether, esters aldehydes, ketones, carboxylic acids etc. The basic concept of various functional groups has been given as below :

(a) Alcohols : These are the simplest compound of carbon, hydrogen and oxygen in which hydrogen atoms of alkanes are replaced by — OH functional group and the compound obtained is called alcohol. Also the alcoholic compound in which only one — OH is present is called monohydric alcohol while that of two — OH is called dehydric alcohol. The compounds like methanol (methyl alcohol), ethenol (ethyl alcohol) etc. are the examples of monohydric alcohol, while glycol is an example of dihydric alcohol. General formula of the members of this series is $C_nH_{2n+1}OH$.

(b) Aldehydes : Organic compounds in which — CHO functional group is present are called aldehydes. General formula of the members of aldehydes are $C_nH_{2n+1}CHO$. The compounds like formaldehyde, acetaldehyde, propional dehyde etc are the examples of aldehydes.

(c) Ketones : Organic compounds in which $> C = O$ functional group is present are called ketones. General formula of the members of this family is $(C_nH_{2n+1})_2$ CO. The compounds like acetone or dimethyl ketone, methyl ethyl ketone, diethyl ketone etc are the examples of ketone.

(d) Carboxylic acids : Organic compounds in which — COOH functional group is present are called carboxylic acids and the general formula of their family's members is $C_nH_{2n+1}COOH$ or $C_nH_{2n}O_2$. The compounds like formic acid, accetic acid, propionic acid, buteric acid etc are the examples of carboxylic acids.

(e) Acid anhydrides : Organic compounds in which RCOOCOR functional group is present are called acid anhydrides. General formula of the members of this family is $(C_nH_{2n+1}CO)_2O$. The compounds like acetic anhydride, porpionic anhydride etc are the examples of acid anhydrides.

(f) Esters : Organic compounds in which — COOR functional group is present are called esters. General formula of the family's members is $C_nH_{2n+1}COOR$ or $C_nH_{2n}O_2$. The compounds like methyl formate, ethyl formate, methyl acetate, ethyl acetate etc are the examples of esters.

The ethyl acetate is used in making artificial perfumes, scented colour, dyes etc.

(g) Ethers : Organic compounds in which —O— functional group is present are called ethers. General formula of family's member is $(C_nH_{2n+1})_2O$. The compounds like dimethyl ether, diethyl ether etc. are examples of ethers.

Diethyl ether is used in the form an anaesthesia and it is also called ether only.

General formulae of organic compounds

Organic compounds	General formulae	Organic compounds	General formulae
Alkane	C_nH_{2n+2}	Ether	$C_nH_{2n+2}O$
Alkene	C_nH_{2n}	Aldehyde and Ketone	$C_nH_{2n}O$
Alkynes	C_nH_{2n-2}	Carboxylic acid	$C_nH_{2n}O_2$
Alcohols	$C_nH_{2n+2}O$	Primary aliphatic amine	$C_nH_{2n+1}NH_2$
Alkyle halides	$C_nH_{2n+1}X$	Carbohydrate	$C_x(H_2O)_y$

4. Some important organic compounds

Methane : This is the first member of alkane's family which is also called Marsh gas. The shape of it is tetrahedral and the angle between two consecutive bonds is of 109°28′. In nature methane is obtained from the decomposition of vegetables and it is the main component of natural gas in which it is found nearly 90%.

In the laboratory it is prepared by heating the mixture of sodium acetate and sodalime. This gas is also prepared by the reaction of aluminium carbide on water, and on the commercial level infact it is manufactured by this process. Methane gas forms an explosive mixture with atmospheric air and due to it sometimes in coal mines powerful explosion takes place. This gas is used in the form of a gaseous fuel, in the preparation of organic compounds, in making carbon black, in the production of hydrogen at industrial level etc.

Ethylene : This is the first member of alkene's family. In the laboratory ethylene is prepared by heating ethyl alcohol with excess conc. H_2SO_4 at nearly 170°C. This is used in making mustard gas, in the form of an anaesthesia, in the production of oxy ethylene flame etc.

Acetylene : This is the first member of alkyle's family and it was firstly discovered by an American's scientist Wilson. It is prepared in the laboratory by the reaction of calcium carbide and water. This is used in the production of light, in making camphor, in the form of an anaesthesia, in the welding and cutting the metallic bodies, in the synthesis of benzene, in the ripening of fruits artificially etc.

Chloro Fluoro Carbon (*CFC*) or Feron : This is basically a composition and combination of chlorine, fluorine and carbon atoms and it plays a significant role in the depletion of ozone layer. This is also called Freon the chemical name of which is Chloro Fluoro Carbon (*CFC*) and it is used in the form of solvent, coolent, preservator etc.

Ethyl alcohol : This is a colourless liquid which is extremely volatile and on drinking human body is stimulated and that's why it is used in making wine. This is obtained by the fruits and starched food grains and on industrial level it is produced by the process of fermentation. It is used as a fuel of motor vehicles, aircrafts, in making transparent soaps, in making perfumes and scented commodities, in the production of wine etc.

Methyl alcohol : This is a deadly poisonous (toxic) liquid whose odour (smell) is like a wine. If a man drinks it then he may be blind and on excess drinking man can die. Most of the death of the people by consuming poisonous wine is caused by methyl alcohol. Early time it was prepared by the process of destructive distillation. This is utilised in the form of a fuel by mixing petrol in it. It is also used in the production of artificial colours, in the form of solvent of barnish etc.

Ethylene Glycol : This is basically a dihydric alcohol sweet in taste and it is used in reducing m.p. of ice in the radiator of cars in the cold regions.

Glycerol : This is a derivative of trihydroxide of propane whose commercial name is Glycerine. It is the main member of trihydric alcoholic series. It is found in the free state in the fermented sugar solution and in small amount in the human blood, while in joint form it is found in fat and vegetable oils in the form of esterified higher organic acids. It is an extremely hygroscopic substance which directly reacts with conc. HNO_3 in the presence of conc. H_2SO_4 and thus Glycerine trinitrate (Tri Nitro Glycerine - *TNG*) is formed. *TNG* is a powerful explosive which is utilised in the manufacturing of dynamite and other explosives. Glycerol is used in making transparent soaps, shoes's polish, synergetic medicines, lubricants, printing ink, cosmetics, antifreezer etc.

Diethyl ether : This is the most important ether of its family and it is also called ether only. This was firstly prepared by a medical practicener of Germany Balerieos Cordus by heating ethyl alcohol with conc. H_2SO_4 and it was firstly synthesised by Williamson. It is used as an anaesthetic agent and it is assumed a better anaesthesia than chloroform.

Chloroform : This was firstly discovered by Lebieg in 1831. Sempson asserted that it is an anaesthetic agent and later he used it in surgical operations. Usually the vapour of chloroform on inhalation ceases the sence organs and thus it is used as an anaesthesia.

Iodoform : This is a yellow coloured crystalline sublimative substance which has a special type of smell (odour). This is insoluble in water and soluble in alcohol and ether. This is also a strong bactericidal substance that's why it is used as an antiseptic in medicine.

Pyrin : This is known as carbon tetrachloride (CCl_4) and this is used in extinguishing the electric fire.

Urea : First time it was obtained from urine in 1773, but it was firstly synthesised in 1828 by Wohler in the laboratory from ammonium cyanate. Urea was the first organic compound which was synthesised in the laboratory and in it nearly 46% nitrogen is to be found. This is a colourless, odourless substance soluble in water. This is found in the urine of living beings. This is used as a fertilizer and additionally it is also used in the production of nitrogen gas, baronal medicines, urea plastic etc.

Formalin : The dilute solution of 40% formaldehyde is called formalin. This is used as the best preservator of the foodstuffs.

Formic acid : This name has been derived from latin word formicus which implies red ants. This is a monocarboxylic acid and the first member of the carboxylic acid family. This acid is basically found in red ants and bees. Firstly the formic acid was prepared by the distillation of water with red ants and that's why it is called formic acid. This is used as a insecticide, in the form of medicine of artherites, in the manufacturing of ruber, leather, cloth etc.

Acetic acid : This is found in free state in the juices of various fruits and specially in vinegar. On the commercial level it is obtained from pyroligneous acid. It is utilised in the form of celulose acetate in making photographic film and Rayon. The dil. solution of acetic acid (4%-6%) is called vinegar.

Oxalic acid : This is a dicarboxylic acid also found in the form of potassium salts in vegetations. This is also found in the form of salt of potassium-hydrogen in the family of plants as Oxalis and Rumex. It occurs in the cells of plant in the form of calcium oxalate. This is also found in very small amount in human urine and sometimes this acid accumulates in the kidney in the form of calcium oxalate and that's why prostate (stone) appears in the kedney. This is used in the form of ferrous oxalate in photography and the ink spot of the garments is also removed by it.

Acetoacetic acid : This is a colourless liquid and on decomposition acetone and CO_2 are obtained. This acid appears excessively in the urine of persons suffering from diabetes.

Pyroligneous acid : This is obtained by the destructive distillation of wood and made from acetic acid, acetone and methyl alcohol.

Citric acid : This is a mono hydroxy tricarboxylic acid which is basically citrous and found in citrous fruits like lemon, orange etc.

Lactic acid : This is a monohydroxy acid which is more soluble in water due to the presence of hydrogen bonds but insoluble in organic solvents. This is present in milk and sourness in the milk appears due to the presence of lactic acid. The human beings feel tired due to the accumulation of lactic acid in the muscles.

Tartaric acid : This is a dihydroxy dicarboxyclic acid which is present in tamarind and grapes. This is used in the manufacturing of baking powder.

Benzene : This is called the father of aromatic compounds and this was firstly discovered by Faraday in 1825. Later Hoffman detected it by the partial distillation of Coaltar and Berthelot which are synthesised a from acetylene gas. It is used as a solvent, in dry cleaning of woolen garments, as a motor vehicle fuel with mixing it with petrol, in the production of various organic compounds, in the manufacturing of explosives etc.

Nitrobenzene : This is also called oil of Mirbane and it is the first member of aromatic nitro compound family. This is obtained by replacing one hydrogen atom of benzene by – NO_2 functional group and firstly it was extracted from Mitscherilich in 1834. This is used in manufacturing of Trinitrobenzene (TNB) which is an explosive.

Aniline : The word aniline has been originated from a Portuese word anil which implies Indigo. Aniline is basically an amino derivative and it was firstly prepared by Unverdorben by the distillation of lime-water and indigo in 1826. Later it was obtained by Runge from coaltar and by Fritsche from heating Indigo with conc. alkali. Aniline is used in ruber industry in manufacturing of drugs, dyes etc.

Phenol : This is a monohydroxy derivative of benzene and it is also called carbolic acid. This was obtained by Runge in 1834 from coaltar. This is obtained by replacing hydrogen of benzene by hydroxyle functional group. This is used in making picric acid (explosive), phenolfthelene, bakelite, salol, asprin, salysalic acid etc.

Benzaldehyde : This is a light brown coloured organic compound which is used in making the delicious spices and in various chemical reactions.

Benzoic acid : This is an aromatic carboxylic acid which is frequently used as foodstuffs preservator.

Salicylic acid : This is a white crystalline aromatic acid which is used in the manufacturing of pain killer medicines.

Toluene : Firstly it was extracted from a resin namely tolubalsam and thus called toluene, its commercial name is Toluol. Toluene is used in the manufacturing of *TNT* explosive, as a solvent, in dry cleaning in sacchrin and chloramine - *T* drugs, with petrol and benzene as an antifreezer etc.

Sacchrin : This is an organic substance which is obtained by the oxidation of tolwen ($C_6H_5CH_3$) and Orthosulphabenzamide ($C_6H_4SO_2CONH$) and it is appeared in the form of sacchrin which is 550 times sweeter than ordinary sugar. The calorefic value of the sacchrin is zero so it is used in bevarage and as sugar for the persons suffering from diabetes.

Naphthalene : This is a poly nuclear hydrocarbon which is used as a germicide and germs do not appear in garments because of the effect of this.

Carbohydrates : This is found abundantly in vegetations and it is of various types like monosacchride, disacchride, trisacchride, oligo sacchride etc. These are the organic compounds which are temporary energy provider (supplier). The compounds like glucose, sugar, starch etc are examples of carbohydrates.

Neoprene : This is a synthetic rubber and obtained from the polymerisation of 2-chloro-butadiene. Neoprene is used in making electrical insulating material, electrical cable, conveyor belt, the pipes of carrying crude oils etc. Also it doesn't burn easily like the natural rubber.

Thiokol : This is another artificial rubber which is obtained from the reaction of dichloro ethane and poly sulphide. It is used in making pipes of carrying crude oils, solvent storage tank etc. Thiokol rubber is mixed up with chemicals which releases oxygen then this mixture is used as a solid fuel for the rocket engines.

Bakelite : This is obtained from heating the phenol and formaldehyde in the presence of sodium hydroxide. It is used in making the body (cabinet) of radio and television, bucket etc.

Polythene : This is a thermoplastic which is obtained from the polymerisation of ethylene. This is used in making pipe, coating of electric wire, packing bags etc.

Rexin : This is an artificial leather and it obtained from the vegetation of cellulose. Good quality rexins are obtained from the coating of pyroxline on the thick canvas.

Teflon : On replacing all four atoms of ethylene by fluorine a compound tetrafluoroethylene (C_2H_4) is obtained in which almost all molecules polymerise and form a plastic called Teflon. Teflon is a non-volatile substance and on it there is no effect of conc. acids and alkalies. This is an extremely useful plastic which is used in making various equipments and devices.

Polyvinyl Chloride : This is obtained from the polymerisation of vinyl chloride and it is used in making thin cover, film, rain coat, water or air filling toys.

Tear gas : This gas is used usually in controlling the uncontrolled mob (crowd). This gas has unique characteristic and when it comes in the contact of eye then there is a bitter burning (pain) in the eyes and tears are produced. There are various tear gas like alpha chloro acetophenon, acrolene etc.

Mustard gas : This is a deadly poisonous gas which was utilised in the chemical weapons during the first world war. It is obtained from the reaction of ethylene and sulphur monochloride and the smell (odour) of this gas is like the mustard oil, so it is called mustard gas. The vapour of the mustard gas produces blister on the skin and this gas strongly damages the lungs. The vapour of the mustard gas even transmits through the rubber.

Lewisite : This is also a poisonous gas like mustard gas which was utilised in the chemical weapons during the second worldwar. When acetylene reacts with arsenic trichloride in the presence of anhydrous aluminium chloride then this gas is obtained.

Chloropicrin : This is a toxic (poisonous) gas which is used during the war and it is obtained from the reaction of chloroform and HNO_3.

Methyl Isocynate (*MIC*) : This is an extremely poisoness (toxic) gas which was leaked out during Bhopal gas tragedy in 1984 through the Union Carbide Company of USA where insecticides were manufactured.

Marsh gas : Methane (CH_4) is called marsh gas and the cause behind the name is occurrence of it inside the moist land. Marsh gas is also found in stored water of the ponds and at moist places in the form of bubbles. Basically this gas originates from the earthened vegetations and bio substances by the decay (decomposition) of bacteria or micro-organism.

Clathret : This is an abundantly occurring gas near the sea shore which is basically the traped methane gas in the molecules of water and this can be utilised in the form of a fuel.

Gobar gas : This is also called Methane gas (volatile) and it originates from the decomposition of weted (moist) gobar which burns easily in the presence of air. Through gobar gas plants which are very common in rural areas of India not only Gobar gas (CH_4) is produced but the residues of gobar are also utilised as bio fertilizers (manures).

Liquified Natural Gas (*LNG*) : Like Liquified Petroleum Gas (*LPG*) it is a liquified form of natural gas in which the main component is methane (CH_4).

LSD : The complete name of it is Lysergic Acid Dithylemide which is used as a dreamy drug.

Aspirin : Aspirin is acetyle salysilic acid and it is a volatile compound. It is used as a pain killer drug.

Paraldehyde : When anhydrated acetaldehyde is heated with conc. H_2SO_4 then paraldehyde is formed and it is used as a sleeping drug.

Urotropine : The chemical name of it is hexamethylene tetramine and it is obtained by reacting formaldehyde with ammonia. It is used in making the medicine of urine.

Chloretone : When acetone reacts with chloroform in the presence of caustic potash (KOH) then chloretone compound is formed. It is used in making the drugs of vomiting or headache which appears during the expedition of mountain or sea.

Gammexene : The chemical name of this compound is Benzene Hexachloride (*BHC*). It is a strong insecticide.

Chloral : This is an oily colourless liquid. It is obtained from the reaction of chlorine and acetaldehyde. The chemical name of chloral is trichloro acetaldehyde and it is mainly used in the manufacturing of *DDT*.

DDT : The complete name of this compound is dichloro diphenyl trichloro ethane. This is used like an important germicide and it is manufactured from chloral.

5. Organic compounds and their uses

Organic compounds	Uses
Methane	Black colour, used in making motor tyre and printing ink, in the production of light and energy, in making methyl alcohol, formaldehyde and chloroform etc.
Butane	In liquid state it is used as a *LPG* fuel.
Ethylene	In fruit ripening and fruits preservator, in making mustard gas, in the form of an anaesthesia, in producing oxy-ethylene flame etc.
Acetylene	In producing light, oxy-ethylene flame, in the form of narselin anaesthesia, in making neoprine (artificial rubber), in artificial fruits ripening etc.
Polythene	In producing electrical resistance in wires and cables, in making layer in the cap of the bottle in the production of non-crackable bottles, pipes, buckets etc.
Polystrene	In the production of caps of bottles of acid, in making the body of the accumulator cells etc.
Ethyl bromide	In making local anaesthesia.

Organic compounds	**Uses**
Chloroform	In surgical operation as an anaesthesia, in form of solvent of rubber, fat, lac etc, as an insecticide etc.
Methyl alcohol	In making methyleted spirit, artificial colour, barnish and polish, mixing with petrol and used as a fuel of engines, etc.
Formamint	In making medicine of throat in making chewing tablets etc.
Ethyl alcohol	In making wine and other alcoholic drinking substances, tincture, barnish and polish, in the form of solvents, in methyleted spirit, in artificial colours of perfumes and scent of fruits, in transparent soaps, in spirit lamps and stoves, in the form of a fuel of motor vehicle in cleaning the wound, in the form of an insecticide etc.
Glyceral	In making nitroglycerine, in cleaning the component parts of watches, in the ink of stamp, in shoes polish and cosmetics, in transparent soaps, in pain reliever medicines of the fractured parts of the body (organs), in sweets, wine and as a fruits preservator etc.
Formaldehyde	In making insecticides, in fixation of giletin film on the photographic plates, in making waterproof cloths by mixing it with eggs exterior whitey part etc.
Acetaldehyde	In making colours and medicines, in manufacturing meta acetaldehyde medicine used in sleeping, in the production of plastic.
Acetone	In making barnish, cardite, clodian celulose, artificial silk, synthetic rubber, sulphone, chlorotone, chloroform, iodoform etc. as medicines.
Formic acid	In making insecticide, as a preservator of fruits juices, in trade of leather, rubber etc.
Acetic acid	As a laboratory's reagent, in the form of vinegar, in making sauces and jelly etc.
Acetyl chloride	In making acetamide, acetic anhydride etc.
Acetic anhydride	In colour industry, in the manufacturing of medicine like aspirin, in making artificial (synthetic) silk from cellulose, etc.
Acetamide	In softening leather, cloth and in moisting pulp and paper.
Ethyl acetate	In making medicines, artificial perfumes etc.
Urea	In the form of fertilizer, in making formaldehyde, urea, plastic, medicines etc.
Benzene	In the form of a solvent, in dry cleaning, by mixing it with petrol and used as a fuel of engines etc.

Organic compounds	Uses
Oxalic acid	In colouration and printing of cloths, in making colour of ink and coaltar, in the bleaching of leather, in cleaning the spot of ink by its 10% solution etc.
Glucose	In making different types of wine, in sweets and preservetors of fruits juices, medicines like gluconate etc.
Toluene	In dry cleaning, in the form of a solvent, in the production of medicines, in making explosives etc.
Chloro benzene	In manufacturing of aniline, phenol etc.
Nitro benzene	In the production of soaps, in the form of mirbane oil, in making polishes and cheap perfumes etc.
Aniline	In trade of colours, in the manufacturing of drugs etc.
Phenol	In the production of carbolic soap, in the form of insecticide, in bakelite, in phenestine, aspirin, celolal etc.
Benzaldehyde	In colour industry, in manufacturing of perfumes etc.
Benzoic acid	In making drugs, as a preservator of fruits juices etc.
Benzene sulphonic acid	In the production of sacchrin, in the production of solute colour, in making sulpha drugs etc.
Ether	As an anaesthesia, solvent, coolent, in the production of alcohol etc.
Carbon tetrachloride	In the form of a fier extinguisher.
Urotropin	In the treatment of urological diseases.
Gammexene	In the form of a germicide/insecticide.

6. Natural sources of organic acids

Organic Acids	Natural Sources	Organic Acids	Natural Sources
Formic acid	In red ants	Tartaric acid	In tamarind
Citric acid	In citrous fruits like lemon, orange etc.	Benzoid acid	In grass, leaves, urine etc.
Oxalic acid	In the tree of sarel.	Lactic acid	In milk
Acetic acid	In juices of fruits	Glumatic acid	In wheat

7. Alcoholic beverages

Wine is an alcoholic beverage which is prepared by the combination of various fermented substances and the amount of alcohol is different in different types of wine.

There are various types of wine like beer, champagne, cider, port and sherry, whisky, Rum, Brandy, Gin etc. In the beer the amount of alcohol is extremely low, while in the Rum this amount is extremely high and the champagne is the most costly wine among all.

Broadly, alcoholic beverage has been classified into two categories—

(i) Distilled beverage : These types of beverages are prepared by the distillation of without distilled beverage and the amounts of alcohol vary from (40-55)% as given below—

Distilled beverage	**% of alcohol**	**Sources**
Whisky	(40-50)%	barley
Rum	(45-55)%	Sugar-cane
Brandy	(40-50)%	grapes
Gin	(35-40)%	maize

(ii) Undistilled beverage : These types of beverage are prepared by the fermentation of fruits juices or food grains and on filteration of fermented liquid and some wanted flavour, colour and perfumes are added (intermixed). The amounts of alcohol vary from (3-15)% as given below;

Undistilled beverage	**% of alcohol**	**Sources**
Beer	(3-6)%	barley
Champagne	(10-15)%	grapes
Port & sherry	(15-25)%	grapes
Cider	(2-6)%	apples

Terms related to alcohol

Wood spirit : Methyl alcohol is also called wood spirit because in early stage it was obtained from the destructive distillation of wood.

Grain alcohol : Ethyl alcohol is also called grain alcohol because it is obtained from the starch enriched substances.

Absolute alcohol : The alcohol which is 100% pure is called absolute alcohol and it is completely pure and anhydrated.

Rectified spirit : This is also called commercial alcohol in which 95.6% ethyl alcohol and 4.4% water coexist.

Power alcohol : The mixture of purified spirit, benzene and petrol is called power alcohol and it is used in propelling engine. As it is directly related to the power of the engine so it is called power alcohol.

Denatured alcohol : Ethyl alcohol which can not be used for the drinking is called denatured alcohol. In order to obtain such type of alcohol usually in purified spirit, methyl alcohol, pyridine, acetone etc. types of toxic substances are mixed up.

8. Petroleum

Petroleum is a natural fuel which is a densely deep black-brown coloured liquid sticky in nature and which has a special smell (odour). Basically it is found in a very deepen site between the sedimentary rock layers inside the Earth's Crust and chemically it is a complex saturated hydrocarbon which is also called crude (mineral) oil. The term petroleum is in fact made from two words – petra + oleum, which implies oil (oleum) of rock (petra). That's why petroleum is also called rock oil. Today petroleum is also called Black Gold or Liquid Gold. The petroleum substances like petrol, kerosene oil, arious hydrocarbons, ether, natural gases etc. are extracted by the method f fractional distillation. Modern concept regarding to it tells that petroleum as been originated from the living beings and vegetations.

Knocking and Octane Number : There are some fuels which are mixed up in the air for the combustion then these fuels burn and produces the heat but this heat of the fuels doesn't transform themself into the exact work and produces metallic sound which is called knocking. Thus those fuels whose knocking is very low are assumed the best fuels and vice-versa. To lower down the knocking some compounds are added in the fuel to make the fuel good and such compounds are called anti knocking compound. The knocking of the fuel is expressed by octane number and it is high for low knocking, so fuel is good and vice-versa. Thus for increasing the octane number of the fuels anti knocking compound is necessarily mixed up. The compound Tetra Ethyl Lead (*TEL*) is the best anti knocking compound. The compound Benzene Toluene Xylene (BTX) is also one of the best anti-knocking compound. Generally 0.15 ml *TEL* is mixed up with ethyl bromide in each litre petrol.

Diesel : This is a type of oily liquid hydrocarbon obtained by the fractional distillation of petroleum. This is cheaper than petrol and a good fuel used in vehicles, machines, devices etc. But during its consumption various toxic gases like sulphur dioxide (SO_2) etc. are evolved. The gas SO_2 creates some problems like irritation in eyes, headache, inhaling problems etc and sometimes skin diseases and respiratory system problems also come into existence.

Ultra Low Sulphur Diesel (*ULSD*) or City Diesel : This is an extremely pure form of diesel. Through the combustion of this diesel less pollutants are spread in the atmosphere because of low sulphur presence in it. It is used frequently in almost all cities of Europe.

Green Diesel : This is the best quality diesel, recognised as Euro-4. In diesel family it is assumed the best because of extremely low pollutants production on its combustion.

Liquified Petroleum Gas (*LPG*) : This is a mixture of hydrocarbons like propane, butane and iso-butane in liquified form at an extremely high pressure. These liquified mixture of hydrocarbons is called LPG which is used as a cooking gas. LPG is obtained by the fractional distillation of natural gas and petroleum. To detect the leakage of LPG some substance of special smell like merkepton etc is mixed up.

Compressed Natural Gas (*CNG*) : This is also a mixture of hydrocarbons (compressed natural gas) found inside the earth's crust in which (80-90)% methane (CH_4) gas exists. This gas emits less CO (about 70%), Nitrogen oxide (87%), bio gases (89%) etc. with comparison to petrol and diesel *CNG* burns at more than 540°C, while petrol burns at 232°C to 282°C. This gas is basically a colourless, odourless, light from air and less pollutant supplier.

CNG is today also used as a fuel of the vehicles but it is compressed upto 200-250 kg per squared cm. This is used in the vehicle as an alternative fuel of petrol and diesel. By the use of *CNG* the deadly toxic substances like lead, CO_2, SO_2 etc. release in very small amount due to which our eco-system remains balanced and pollution level is under control.

Gasohol : Gasohol was first discovered in Brazil. The mixture of petrol (10%) and alcohol (90%) is called gasohol, and it is obtained by mixing petrol in the extracted alcohol of sugarcane. By the use of gasohol as a fuel in the vehicles the pollutants like CO_2, SO_2 etc. can be reduced and minimised upto an extremely lower level. Thus gasohol can be a better alternative option of the petrol because of great demand of petrol.

9. Soap and Detergent

Soap : Usually soaps are sodium salts of higher fatty acids like pamitic acid ($C_{15}H_{31}COOH$), staric acid, oleic acid ($C_{17}H_{33}COOH$) etc. The soaps made from these acids are called sodium pamitate ($C_{15}H_{31}COONa$), Sodium stariate ($C_{17}H_{35}COONa$) and sodium Olciate ($C_{17}H_{33}COONa$) respectively.

Characteristics of good soaps : There should be no free alkali in the soap, the soap must be soluble in alcohol, the moisture should not be present more than 10% and soap should not be cracked during the use.

Detergent : This was firstly invented during the first world war in Germany. The detergent is a substance prepared by the highly fatty acids extracted from various vegetative oils through which the dirty cloths and garments are washed out. For cleaning the cloths or garments by the use of ordinary soap there is a need of more labour and with hard water this problem is more serious. Thus to remove such difficulties chemists searched the way to clean these cloths or garments more easily, conveniently and cheaply and these were called detergents.

Types of detergents	**Examples**
Sodium alkyle sulphate	Sodium lorel sulphate.
Partially esterified compound	Penta arithroatal monostiarate.
Tetra ammonium salt.	Tri methyl starium ammonium bromide.
Displaced alkyle sulphonate	Sodium *P*-dodesil benzene sulphonate.

Difference between soap and detergent

Soaps	**Detergents**
This is not appropriate to clean cloths with hard water because Ca^{++} and Mg^{++} ions directly combine with soap and a white oily compound forms which prevents to form leather.	This can be suitably used in cleaning the cloths because detergent does not forms any insoluble precipitate with Ca^{++} and Mg^{++} ions.
Soaps exhibit lesser humidity.	But detergents exhibit more humidity.
Soaps do not produce any deadly toxic pollutant even in excess use because they form only biodegradable substances with cloths.	But detergents produce deadly toxic pollutants and it is non-biodegradable.
Soaps are prepared by the substances (materials) obtained from the petroleum.	While detergents are prepared by the substances (materials) obtained from vegetable oils.

Oils and fats are the ester formed by highly fatty acids and unsaturated acids with glycerol. Thus almost all oils and fats are the complex mixtures which are obtained by pamitic, staric and olic acids with glycerol. The oils and fats differ physically but both belong to the same class. Usually at an ordinary temperature the glycerides which are found to be in the solid state is called fat, while the glycerides which are liquid at an ordinary temperature is called oil. The oils and fats can also be differentiated on the basis of their b.p's and according to this concept the glycerides whose b.p's are less than 20°C are the oils while those glycerides whose b.p's are more than 20°C are the fats.

Some vegetable oils like oil of date has a greater amount of unsaturated glycerides and when through such oils H_2 gas is passed out in the presence of a suitable catalyst then these glycerides transform into solid state and reduces into the fat. This is the process of preparation of vegetable ghee (Clared butter). Edible fats must have the b.p's below than the temperature of the human body (37°C).

11. Waxes

Wax is also an ester which exists in nature like oil and fat but the ester is different from ester glyceride. In wax the molecules of highly fatty acids on the behalf of glycerol reacts with monohydric alcohol and forms a complex ester. Some common types of waxes are given as below;

1. Waxes of bees of honey : Mainly it contains merisil pamitate.
2. Karnoba waxes : Obtained from palm leaf and in it merisil ceratate is to be found.
3. Spermty waxes : Obtained from the sperms of whale and in it setil pamitate is to be found.
4. Paraffin waxes : Mixture of higher hydrocarbons which is obtained from petroleum.

12. Plastic

When the unsaturated hydrocarbons like ethylene, propylene, butylene etc undergo the process of polymerisation under suitable conditions then higher polymer is obtained and it is called plastic. We can also say that the plastic is a substance which remains soft during its course of preparation and can be shaped in any form.

Usually there are two types of plastics—

1. Natural plastic : The plastic which on heating turns soft, while on cooling turns hard is called natural plastic.

The tree of eucalyptus is the best example of natural plastic.

2. Artificial plastic : The plastic formed by the chemical process is called artificial plastic and it is of two types—

1. Thermo plastic : The plastic which on heating becomes soften while on cooling becomes harden is called thermo plastic and this characteristic is maintained through out its existence. Thermo plastic is obtained by the process of addition polymerisation of the organic compounds of double bonds. The polymers like polyethylene, poly vinyl chloride, polystyrene, nylon, teflon etc are the examples of thermo plastics.

2. Thermosetting plastics : The plastic which on heating firstly becomes soften and an arbitrary shape can be given to it but if it again be heated then it doesn't remain soften and this irreversible polymerisation process is called thermosetting plastic. Thus obtained irreversible polymers are also called rigid temperature polymers. The examples of thermosetting plastics are Glyptal, Vectal, Bakelite etc.

13. Rubber

This is obtained from the milk of some special types of the trees found in the equatorial evergreen forest and this milk is called Latex. Early time this was frequently used to erase the mark made by the graphite pencil on the plane white papers and it is called rubber. Later due to some unique characteristics like elasticity, water resistance, bad conductivity of heat and electricity etc these rubbers are started to be use in various industries for various purposes. In the primitive days rubbers were obtained in the product forms of forests of Amezan and Zarie. In Amezan river basin Dhone place was the main region of the rubber production and so it (rubber) was also called wild rubber. Later in 20th century the plantation of rubber was started in Malaya and in South-East Asia.

There are two types of rubber—

1. Natural rubber : Natural rubber is obtained from some special types of milk of trees called latex. Thus it is the rubber which is obtained naturally and almost all rubber (natural) is the polymer of Isoprene (C_5H_8).

2. Synthetic rubber : The rubber which is produced chemically and artificially is called synthetic rubber and outstanding contribution with regard to its discovery goes to Mathews and Hariss. Mathews and Hariss extracted a polymer like natural rubber on heating isoprene with sodium at 60°C, and called it synthetic rubber. There are so many synthetic rubbers like polystyrene, Dupren rubber, Neoprene rubber, thiokol rubber, polyvinyl chloride etc.

14. Fibres

The solid substance which has a long chained structure and which is so many times longer and larger than breadth is called fibre.

Synthetic fibres : These are the polymers of so many simple molecules which have been composed and combined in laboratories. The synthetic substances Rayon, Nylon, Polyester etc. are the examples of synthetic fibres.

Some important synthetic fibres :

Nylon : The word NYLON has been composed from two words NY of New York (city of America) and LON of London (capital of UK). Nylon is basically forms by the polymerisation process of smaller and simpler organic molecules which doesn't exist in nature, it is an example of poly amide fibre in which amide functional group is present in each unit, and which is repeated again. Also Nylon was the first fibre obtained synthetically. Firstly it was prepared in 1935 and on commercial level scarf (a woman's garment) was prepared in 1939. At present Nylon is used frequently in making net of fish trapping, cloths of parachute, tyre, teeth, brushes, ropes etc.

Rayon : The artificial fibres made of cellulose is called Rayon and the Cellulose is extracted from the wood paste or pulp paper. Firstly the cellulose is oxidised in conc. and cold NaOH and CS_2 then the residues in the form of cellulose solution is passed out through the holes of metallic cylinder and dil. H_2SO_4 is poured due to which very long fibres are prepared. Rayon is chemically a pure cotton and it is used in making cloths, carpets, pharmaceutical lint or porous thick paper etc.

Polyster : Firstly, it was developed and composed in UK. In order to synthesise the polyester two hydroxyle (–OH) groups carbonous compound chemically react with two carboxyle (– COOH) groups and ester is formed. Also since in this fibre there are so many ester groups thus it is called polyester. Polyester is used in the form of cloths, in making housepipes of fire extinguishers.

Carbon fibres : Carbon fibres are made from long chains of carbon atoms in which the incident of corrosion doesn't take place. When the synthetic fibres are heated in the absence of oxygen then fibres start to decompose and carbon fibres are formed. Carbon fibres are used in making parts of space vehicles and sports items.

15. Explosives

The substances which on the combustion provides extreme heat and energy with a strong cracking sound are called explosives. There are various explosives but some of them are important which are—

RDX (Research & Development Explosive) : RDX was firstly invented by a German chemist Haning in 1899 in the form of a pure white crystallined powder. The chemical name of RDX is cyclo trimytheline trinitramine and sometimes it is also called plastic exploder and this explosion in USA is called cychlonite, in Germany it is called Hexogen and in Italy it is called T–4. If plastic substance like poly butinc acrilic acid is mixed up in RDX in very small amount then Plastic Bonded Explosive (PBE) is obtained. Another form of explosive is C–4 which is a deadly destructor (cracker) and to achieve an optimal level of requirement some powder of aluminium is mixed up. Plastic Bonded Explosive (PBE) is today frequently used by the terorists and fundamentalist group. The explosion energy in normal RDX is nearly 1510 kcal.

TNG (Tri Nitro Gylecrine) : It is a colourless oily liquid which is used in making dynamite. TNG is also called Nobel's oil. This explosive was invented in 1846. It is prepared by mixing conc. H_2SO_4 and conc. HNO_3 in Glycerine.

TNT (Tri Nitro Toluene) : This is the most frequently used explosive and it is prepared by the reaction of toluene ($C_6H_5 - CH_3$), conc. H_2SO_4 and conc. HNO_3. This explosive was firstly invented in 1863 while its commercial level used was started in 1914 and the first user of TNT was UK troops.

Dynamite : This is also an explosive which was invented by Nobel Alfred in 1863. This is prepared by absorbing inert substances like powder of wood or absorbing in Kieselguhr. At present in making dynamite on the behalf of nitro glycerine sodium nitrate is used. In xelatine dynamite a very small amount of nitro cellulose is mixed up.

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TNP (Tri Nitro Phenol) : This is also known as picric acid and TNP is prepared by the reaction of phenol with conc. H_2SO_4 and conc. HNO_3. TNP is also a ultra exploder explosive.

16. Drugs and Chemicals

1. Anaesthesia : Anaesthetic drugs are basically used in order to cease the scence organs specially during the major surgical operation etc. The first time anaesthesia was used by William Morten in 1846 in the form of diethyl ether. Later in 1847 it was used by James Sampson in the form of chloroform. There are also so many compounds like sulphonal, veronal, chloropropane, cocaine, diagipalm, pentothal sodium, Halothane, nitrous oxide etc, which are used as anaesthesia.

2. Antibiotics : Antibiotic drugs are prepared by micro organism, moulds, fungi etc and these drugs kill another organism and examine the growth (spread) of virus and bacteria. Alexander Flemming firstly invented the drug Penicilin (antibiotic) in 1929 which is used a destroyer of virus, bacteria and fungi.

Some more important antibiotics which are used frequently are—

Tetracycline, Cephalosporins, Streptomycin, Gentamycin, Rifamycin, Chloromycitin etc.

3. Antiseptics : Antiseptic drugs are helpful in killing micro organism (virus and bacteria) and in preventing its spread. This is specially used to prevent the blood to be polluted and in cleaning wounds by suitable antiseptics. There are three antiseptic substances—Semmelwies, Lister and Koch which are today frequently used in making antiseptics. Some antiseptic drugs which are commonly used are Iodine, Hypochlorous acid, Ethyl alcohol, phenols Hexachlorophene, Formaldehydes, Hydrogen peroxide, Acriflavine etc.

4. Antipyretics : Antipyretics are used as a body pain reliever and in the form of medicine of fever etc. Some important antipyretic drugs are—Asprin, Crocin, Phenacitin, Pyromidin etc.

5. Sulpha Drugs : These drugs are mainly composed from sulphur and nitrogen and such drugs are strongly effective against certain organisms. Some sulpha drugs are used specially for animals. The first sulpha drug was sulphanylmide which was invented and formed in 1908.

Some important sulpha drugs are—

Sulphanylmide, Sulphadigene, Sulphapyridene, Sulphathiogol etc.

Miscellaneous

(I) Important discoveries of chemistry

Discovery	Discoverer	Discovery	Discoverer
Nitrogen	Rutherford	Uncertainty principle	Heisenberg
pH scale	Lowrance	Radioactivity	H. Bacqueral
Heavy water	Ure	Group displacement law	Soddy & Fajan
Calcium	Devi	Law of partial pressure	Dalton
Sodium	Devi	Law of inverse ratio	Rietcher

Discovery	Discoverer	Discovery	Discoverer
Potassium	Devi	Photo electric effect	Einstein
Isotope	Soddy	Electro valency	Kossel
Dilution law	Ostwald	Artificial radio activity	Juliot / Juliate
Catalyst	Berzealius	Theory of wave mechanics	de Brogeli
Hydrogen	Cauvendish	Theory of relativity	Einstein – Novel-1924
Chlorine	Shielley	Mass energy relation	Einstein
Covalencey	Lewis	Law of mass action	Lovieser
Helium	Locare	Polenium	Madam Curie
Nucleus	Rutherford	Exclusion principal	Paulli
Thorium	Berzealius	Atomic Number	Moseley
Uranium	Cloproth	Radium	Curie Couple
Proton	Goldstein	Modern periodic table	Moseley
Electron	J. J. Thomson	Old periodic table	Mendleeve
Neutron	J. Chadwick	Law of gaseous diffusion	Grahm
Octate rule	Nelands	Max. Multiplicity rule	Hund
Magnesium	Devi	Treble law	Dobrineor
Messon	Yukawa	Quntum theory	Max. Planck
Positron	Anderson	Atomic theory	J. Dalton
Oxygen	Shielley & Pristley	Law of electrolytic decomposition	Faraday
Argon	Ramssa & Raleigh	Law of constant proportion	Prout

(II) Chemical formulae, commercial name of chemical compounds

Commercial Name	Chemical Compounds	Chemical formulae
Common salt	Sodium chloride	$NaCl$
Baking soda	Sodium bicarbonate	$NaHCO_3$
Washing soda	Sodium carbonate	$Na_2CO_3 . 10H_2O$
Caustic soda	Sodium hydroxide	$NaOH$
Chilli salt peter	Sodium nitrate	$NaNO_3$
Borax	Sodium borate	$Na_2B_4O_7 . 10H_2O$
Soda ash	Sodium carbonate	Na_2CO_3
Globour salt	Sodium sulphate	$Na_2SO_4 . 10H_2O$
Hypo	Sodium thiosulphate	$Na_2S_2O_3 . 5H_2O$
Microcosmic salt	Sodium ammonium hydrogen phosphate	$NaNH_4 + HPO_4$
Potash alum	Potassium aluminium sulphate	$K_2SO_4 . Al_2(SO_4)_3 . 24H_2O$

Commercial Name	Chemical Compounds	Chemical formulae
Red medicine	Potassium permangnet	$KMnO_4$
Niter	Potassium nitrate	KNO_3
Chrome alum	Potassium chromium sulphate	$K_2SO_4 \cdot Cr_2(SO_4)_3 \cdot 24H_2O$
Bleaching powder	Calcium oxy dichloride	$Ca(OCl)Cl$ or $CaOCl_2$
Lime water	Calcium hydroxide	$Ca(OH)_2$
Gypsom	Calcium sulphate	$CaSO_4 \cdot 2H_2O$
Plaster of paris	Calcium sulphate hemihydrate	$CaSO_4 \cdot 1/2H_2O$
Chalk or Marble	Calcium carbonate	$CaCO_3$
Slaked lime	Calcium oxide	CaO
Lime stone	Calcium carbonate	$CaCO_3$
Hydrolith	Calcium hydride	CaH_2
Sal-ammoniac	Ammonium chloride	NH_4Cl
Laughing gas	Nitrous oxide	N_2O
Letharg	Lead oxide	PbO
Galena	Lead sulphide	PbS
Red vermillian	Lead peroxide	Pb_3O_4
White lead	Basic lead carbonate	$2PbCO_3 \cdot Pb(OH)_2$
Acid of salt	Hydrogen chloride	HCl
—	Nitric acid	HNO_3
Meuretic acid	Hydro chloric acid	HCl
Oil of vitriol	Conc. sulphuric acid	conc. H_2SO_4
Aquaregia	Mixture of conc. nitric acid and conc. hydrochloric acid (1 : 3)	$HNO_3 + 3HCl$
Water gas	Mixture of carbon monoxide and hydrogen	$CO + H_2$
Oleum	Fuming sulphuric acid	$H_2S_2O_7$
Bauxite	Hydrates alumina	$Al_2O_3 \cdot 2H_2O$
Solid ice	Solid carbondioxide	CO_2
Green vitriol	Ferrous sulphate	$FeSO_4 \cdot 7H_2O$
Magnesia	Magnesium oxide	MgO
Horn silver	Silver chloride	$AgCl$
Lunar caustic	Silver nitrate	$AgNO_3$
Black zinc	Zinc sulphide	ZnS
White vitriol	Zinc sulphate	$ZnSO_4 \cdot 7H_2O$

Commercial Name	Chemical Compounds	Chemical formulae
Chinese white	Zinc oxide	ZnO
Quick silver	Mercury	Hg
Calomel	Mercuric chloride	Hg_2Cl_2
Vermilian	Mercuric sulphide	HgS
Corrosive sublimate	Mercurous chloride	$HgCl_2$
Heavy water	Duetereum oxide	D_2O
Heavy hydrogen	Duetereum	D
Silica	Silicon dioxide	SiO_2
Carbendum	Silicon carbide	SiC
Arsin	Arsenic hydride	AsH_3
Blue vitriol	Copper sulphate	$CuSO_4 . 5H_2O$
Lithopone	Mixture of zinc sulphide and barium sulphate	$ZnS + BaSO_4$
Producer gas	Mixture of carbon monoxide and nitrogen gas	$CO + N_2$
Marsh gas	Methane	CH_4
Gammaxine	Benzene Hexachloride (BHC)	$C_6H_6Cl_6$
Phosgene	Carbonyl chloride	$COCl_2$
Vinegar	dilute solution of acetic acid	CH_3COOH
Alcohol	Ethyl alcohol	C_2H_5OH
Wood spirit	Methyl alcohol	CH_3OH
Starch	—	$C_6H_{10}O_5$
TNB	Tri Nitro Benzene	$C_6H_3(NO_2)_3$
TNT	Tri Nitro Toluene	$C_6H_2CH_3(NO_2)_3$
Juice of grapes	Glucose	$C_6H_{12}O_6$
Farmeline	10% solution of formal dehyde	dil. HCHO
Feron	Dichloro difluoro carbon	CF_2Cl_2
Urea	Carbamyde	NH_2CONH_2
Chloroform	Tri chloro methane	$CHCl_3$
Iodoform	Tri iodo methane	CHI_3
Pyrine	Carbon tetra chloride	CCl_4
Phenol	Hydroxy benzene or carbolic acid	C_6H_5OH
[illegible]	Methyl isocyanate	CH_3NC

III) Alloys, composition and their uses

The chemical composition and a definite combination of one or more metals and non-metal in the form of a homogeneous mixture is called alloy. But if in the alloy one metal is mercury then alloy is called amalgam.

Some important alloys—

Alloys	Composition	Uses
Brass	Cu–70%, Zn–30%	In making wires, parts of machines, utensils etc.
Bronze	Cu–90%, Sn–10%	In making utensils, idols etc.
Artificial gold	Cu–90%, Al–10%	In making ornaments, idols etc.
Coins metal	Cu–95%, Sn–4%, P–1%	In making coins and costly idols.
Gun metal	Cu–88%, Sn–10%, Zn–2%	In making fire arms like gun, pistol, equipments of machines.
Bell metal	Cu–80%, Sn–20%	In making bells which are used in schools and temples.
Constanton	Cu–60%, Ni–40%	In making wires.
Monal metal	Cu–28%, Fe–2%, Ni–70%	In making idols.
German silver	Cu–50%, Zn–35%, Ni–15%	In making utensils idols etc.
Dutch metal	Cu–80%, Zn–20%	In making parts of machines, devices etc.
Magnelium	Al–5%, Mg–95%	In making aircrafts and aeroplane.
Durelumine or Hydroleum	Al–95%, Mg–1%, Cu–4%	In making aircrafts, pressure cookers etc.
Aluminium bronze	Al–10%, Cu–90%	In making utensils, coins, artificial ornaments, paint etc.
Nichrome	Ni, Fe, Cr, Mn	In making electric heater, good quality electric wires etc.
Solder	Pb–68%, Sn–32%	In welding metallic bodies, filling cracked metallic parts.
Alanko	Fe, Al, Ni, Co	In making magnet.
Manganese steel	Mn–14%, Fe–(80–85)%	In making lockers, fish plates of railway tracks, part of cutting machines etc.
Chromium steel	Cr–2.4%, C–1.5%, Fe–(90–95)%	In making cutting machines, shaving blades, bullets of gun and pistol etc.

Objective Questions

The atom of which of the following element has the smallest nucleus?
(a) Nitrogen (b) Oxygen (c) Hydrogen (d) Helium

Who was the inventor of atomic theory ?
(a) Rutherford (b) Madam Curie
(c) John Dalton (d) Albert Einsten

3. Nucleon is the name which is used for :
(a) electron and proton (b) proton and neutron
(c) electron and neutron (d) None of these *[BPSC ASI 2002]*

4. Consider the following :
1. Carbondioxide 2. Oxides of Nitrogen 3. Oxides of Sulphur
Which of the above is / are the emission / emissions from coal cumbustion at thermal power plants ?
(a) 1 only (b) 2 and 3 only (c) 1 and 3 only (d) 1, 2 and 3
[CSAT-IAS (Pre) 2011]

5. Minerals are :
(a) liquids (b) inorganic solids
(c) gases (d) all of the above *[BPSC 2011]*

6. The number of neutrons and protons in the nucleus of ${}_{88}Ra^{226}$ are :
(a) 138 and 88 (b) 88 and 138 (c) 226 and 88 (d) 88 and 226

7. Who was the inventor of radioactivity :
(a) Madam Curie (b) Irine Curie
(c) Henery Bacqurel (d) Rutherford

8. A single type of atom is found in :
(a) compounds of minerals (b) mixture of minerals
(c) natural elements (d) none of the above *[BPSC 2011]*

9. Which one of the following is negatively charged ?
(a) α-rays (b) β-rays (c) γ-rays (d) *X*-rays
[BPSC (Pre) 2002]

10. Table salt (NaCl) is a product of :
(a) weak acid and weak base (b) strong acid and strong base
(c) weak acid and strong base (d) strong acid and weak base
[BPSC (Pre) 2011]

11. Which of the following is not a radioactive element ?
(a) astetin (b) franscium (c) titenium (d) zeronium
[IAS (Pre) 2001]

12. Artificial silk is also called :
(a) rayon (b) dacron (c) fibre glass (d) nylon
[JPSC (Pre) 2011]

13. The elements of a group in the periodic table
(a) have similar chemical properties
(b) have consecutive atomic numbers (d) are isotopes *[CDS, 2012]*
(c) are isobars

14. The half life of a radioactive substance is 4 months then the time spent in decaying $\frac{1}{4}$ th of the substance would be :
(a) 3 months (b) 4 months (c) 8 months (d) 12 months
[IAS (Pre) 2001]

✓15. The estimation of the age of the earth is done by :
(a) uranium dating (b) carbon dating
(c) atomic clock (d) bio clock

16. In the isotope of an atomic nucleus :
(a) number of neutrons are same but number of protons are different
(b) number of protons are same but number of neutrons are different
(c) both number of protons and neutrons are same
(d) both number of protons and neutrons are different

[BPSC 1996]

17. Cooking gas is a mixture of :
(a) carbon monoxide and carbon dioxide
(b) butane and propane (c) methane and ethylene
(d) carbondioxide and oxygen

[JPSC (Pre) 2011]

18. The pH of fresh ground water slightly decreases upon exposure to air because—
(a) Carbon dioxide from air is dissolved in the water
(b) Oxygen from air is dissolved in the water
(c) The dissolved carbon dioxide of the ground water escapes into air
(d) The dissolved oxygen of the ground water escapes into the air

[CDS, 2012]

19. Cobalt-60 is commonly used in radiation therapy, because it emits :
(a) alpha rays (b) beta rays (c) gamma rays (d) X-rays

[JPSC (Pre) 2011]

20. Which of the following is not an isotope of hydrogen ?
(a) protium (b) duterium (c) iterium (d) tritium

21. $_8O^{16}$, $_8O^{17}$, $_8O^{18}$ are called :
(a) isotopes (b) isotones (c) isobars (d) isoneutrons

[BPSC (ASI) 2002]

22. The radioactive isotope of hydrogen is called :
(a) duterium (b) protium (c) radium (d) tritium

23. Carbon dioxide is called a green house gas because—
(a) Its concentration remains always higher than other gases
(b) It is used in photosynthesis (c) It absorbs infrared radiation
(d) It emits visible radiation

[CDS, 2012]

24. In a dry cell, which of the following are used as electrolytes ?
(a) Ammonium chloride and zinc chloride
(b) Ammonium chloride and calcium chloride
(c) Magnesium chloride and zinc chloride
(d) Sodium chloride and zinc chloride

[JPSC (Pre) 2011]

25. The iso electronic of Al^{+3} is :
(a) Cl^- (b) Al (c) S^{--} (d) F^- [CDS 2001]

26. Which is the second most abundant metal in the earth's crust ?
(a) Iron (b) Aluminium (c) Copper (d) Zinc

[JPSC (Pre) 2011]

27. Age of fossil may be found out by determining the ratio of two isotopes of carbon. The isotopes are—
(a) C–12 and C–13 (b) C–12 and Carbon block
(c) C–12 and C–14 (d) C–13 and C–14 [CDS, 2012]

28. Teflon is a/an
(a) fluorocarbon (b) hydro carbon
(c) pesticide (d) insecticide [JPSC (Pre) 2011]

29. The shape of ethylene molecule is :
    (a) linear (b) tetrahedral
    (c) coplanar triangular (d) hectohedral
30. Which of the following compound is tetrahedral ?
    (a) ammonia (b) carbon tetrachloride
    (c) water (d) acetylene
31. Which one of the following polymeric materials is used for making bulletproof jackets ?
    (a) Nylon 6, 6 (b) Rayon (c) Kevlar (d) Dacron
    [JPSC (Pre) 2011]
32. The nucleus of a singly ionized carbon atom contain—
    (a) 6 protons and 6 neutrons (b) 5 protons and 6 neutrons
    (c) 6 protons, 6 neutrons and 6 electrons
    (d) 12 protons, 6 neutrons and 6 electrons
    [NDA, 2012]
33. Which one among the following nitrogen compounds has the least percentage of nitrogen by mass ?
    (a) $(NH_4)_3PO_4$ (b) NH_3 (c) NH_4OH (d) NH_4NO_3
    [NDA, 2012]
34. Which one among the following is the correct order of amount of lime (CaO), Silica (SiO_2), Alumina (Al_2O_3) and ferric oxide (Fe_2O_3) in portland cement ?
    (a) $CaO > SiO_2 > Al_2O_3 > Fe_2O_3$ (b) $SiO_2 > CaO > Fe_2O_3 > Al_2O_3$
    (c) $Al_2O_3 > SiO_2 > CaO > Fe_2O_3$ (d) $Fe_2O_3 > Al_2O_3 > SiO_2 > CaO$
    [NDA, 2012]
35. Which one among the following is the major constituent of soda lime glass ?
    (a) sodium oxide (b) calcium oxide
    (c) calcium carbonate (d) silica *[NDA, 2012]*
36. In which of the following chlorine has + 1 oxidation number ?
    (a) hypochlorous acid (b) hydrochloric acid
    (c) zinc chloride (d) chlorine *[CDS 1999]*
37. Which of the following is not a metallic mineral ?
    (a) haematite (b) bauxite (c) gypsum (d) lemonite
    [JPSC (Pre) 2011]
38. Which of the following does not pollute ?
    (a) copper (b) cadmium (c) arsenic (d) Nickel
    [MPPCS (Pre) 2011]
39. The element whose oxidation state in its every compound is same is :
    (a) carbon (b) fluorine (c) hydrogen (d) oxygen
    [CDS 2002]
40. The oxidation state of oxygen in OF_2 is :
    (a) + 2 (b) − 2 (c) + 1 (d) − 1 *[CDS 2000]*
41. The acid is a substance which :
    (a) accepts (gains) electron (b) donates electron
    (c) provides (donates) proton (d) donates OH^- ion
42. Which acid substance is found in vinegar ?
    (a) Lactic Acid (b) Citric Acid (c) Maleic Acid (d) Acetic Acid
    [MPPCS (Pre) 2011]

43. Which one of the following compounds is used as freezerd medicine?
(a) KBr (b) $CaCl_2$ (c) C_2H_5OH (d) PCl_3
[UPPCS (Pre) 2010]

44. The solution of Hypo which is frequently utilized in the photography is an aqueous solution of—
(a) Sodium thiosulphate (b) Sodium tetra thionate
(c) Sodium sulphate (d) Ammonium persulphate
[UPPCS (Pre) 2010]

45. Which one of the following heaviest element is of nickel group ?
(a) Platinum (b) Radium (c) Plodium (d) Iron
[RRB TC 2009]

46. Iron nails are dipped into blue copper sulphate solution. After some time iron nails are—
(a) dissolved and blue colour is discharged
(b) dissolved but blue colour is not discharged
(c) not dissolved and blue colour is not discharged
(d) not dissolved but blue colour is discharged
[NDA, 2011]

47. The average *pH* value of the milk is :
(a) 6.1 (b) 6.6 (c) 7.4 (d) 8

48. Mohr salt is a
(a) simple salt (b) hybrid salt (c) double salt (d) complex salt

49. A student by chance mixed acetone with alcohol. This mixture of acetone and alcohol can be separated by—
(a) Filtration (b) Separating funnel
(c) Fractional crystalization (d) Fractional distillation
[NDA, 2011]

50. In which of the following silver is not to be present ?
(a) Horn silver (b) German silver
(c) Ruby silver (d) Lunar caustic [IAS (Pre) 2007]

51. The metal which forms hydrogen after the reaction of an acid with an alkali is :
(a) Zinc (b) Sodium (c) Potasium (d) Calcium
[MPPCS (Pre) 2009]

52. The air is an example of :
(a) the solution of solid in the gas (b) the solution of gas in the gas
(c) the solution of liquid in the gas (d) the solution of liquid in the solid

53. The milk is an example of :
(a) Solution (b) Collidal solution
(c) emulsion (d) air-solution [BPSC (Pre) 1998]

54. The *pH* value of a solution is 6 then the hydrogen ion concentration of the solution would be :
(a) 10^{-6} M (b) 10^{-10} M (c) 10^{10} M (d) 10^{6} M

55. The hydrogen ion concentration of a solution is 10^{-4} M then the concentration of hydroxyl ion in it would be :
(a) 10^{-4} (b) 10^{-14} (c) 10^{-10} (d) 10^{4}

56. Which of the following is called philosopher's wool ?
(a) Zinc bromide (b) Zinc nitrate
(c) Zinc oxide (d) Zinc chloride [IAS (Pre) 2007]

In which of the following form alum is used ?
(a) as a pain killer (b) as a fertilizer
(c) as an antiseptic (d) as a waterpurifier [NDA 2009]

In the process of electrolysis oxidation occurs at :
(a) cathode (b) anode (c) both of these (d) None of these

In the process of electrolysis reduction occurs at :
(a) cathode (b) anode (c) both of these (d) None of these

Which of the following is used in the form of an electrolyte of the dry cell (battery) ?
(a) Ammonium chloride and zinc chloride
(b) Sodium chloride and calcium chloride
(c) Magnesium chloride and zinc chloride
(d) Ammonium chloride and calcium chloride [IAS (Pre) 2007]

61. The iron container (vessel) is galvanized by :
(a) Chromium (b) Zinc (c) Aluminium (d) Nickel
[Jharkhand PCS (Pre) 2008]

62. Silver ware turns black after a period of time due to formation of—
(a) nitrate coating on silver (b) sulphide coating on silver
(c) chloride coating on silver (d) oxide coating on silver
[NDA, 2011]

63. Which one among the following methods is not effective in removing arsenic from contaminated ground water ?
(a) Boiling (b) Coagulation adsorption
(c) Ion exchange (d) Reverse osmosis [NDA, 2011]

64. Cryolite is an ore of which one of the following metal ?
(a) Antimony (b) Barium (c) Arsenic (d) Aluminium
[CDS 2008]

65. Usually doctors recommend the foodstuffs which are prepared in the oil with comparison to the vegetable ghee because ;
(a) oil has unsaturated fats (b) oil has saturated fats
(c) to store the oil is convenient (d) oil is cheeper
[Uttrakhand PCS (Pre) 2008]

66. Which one of the following pairs of gases mainly cause the explosion in the land mines ?
(a) H_2 and O_2 (b) Oxygen and acetylene
(c) Methane and air (d) Carbondioxide and methane
[IAS (Pre) 2008]

67. The catalyst used in the hydrogenation process of the oils is :
(a) Fe (b) Ni (c) Mo (d) Pt

68. Which of the following is another name of RDX :
(a) Cynohydrine (b) Deestron
(c) Cychlohexane (d) Cychlonite [IAS (Pre) 2007]

69. The catalyst used in the production of H_2SO_4 by the Contact process is/are :
(a) pieces (powder) of iron (b) pieces (powder) of platinum
(c) oxide of nitrogen (d) nickel

70. The catalyst used in the production of ammonia by the Haber's process is :
(a) nickel (b) iron (c) platinum (d) molybdenum

71. Bronze is often used to make statues and medals whereas brass is used in making utensils, scientific apparatus and cartridges. Both brass and bronze are copper containing alloys, yet they differ in their chemical composition for additionally containing—
(a) Zinc in brass and tin in bronze
(b) Chromium in brass and nickel in bronze
(c) Nickel in brass and tin in bronze
(d) Iron in brass and nickel in bronze
[NDA, 2011]

72. When the water vapour is poured on the red heated coke then the mixture of carbon monoxide and hydrogen gas is produced which is :
(a) coal gas (b) water gas (c) producer gas (d) biogas

73. The gaseous mixture of carbon monoxide and nitrogen is called :
(a) coal gas (b) water gas (c) producer gas (d) natural gas

74. The main component of the natural gas is :
(a) methane (b) ethane (c) propane (d) butane

75. Which one of the following is a component of tear gas ?
(a) Ethane (b) Ethanol (c) Ether (d) Chloropicrine
[SSC Graduate Level (Pre) 2010]

76. Which one of the following has the maximum calorific value :
(a) hydrogen (b) charcoal (c) natural gas (d) gasoline
[IAS (Pre) 1997]

77. Which one of the following periodic properties of the elements does not exhibit the specific characteristic ?
(a) Atomic size
(b) Valency
(c) Radioactivity
(d) Electron negativity *[NDA 2010]*

78. Which among the following is the correct increasing order of pH found in human body ?
(a) Gastric juice, saliva, blood
(b) Blood, saliva, gastric juice
(c) Saliva, blood, gastric juice
(d) Gastric juice, blood, saliva
[CDS, 2010]

79. The brown coal is :
(a) peat (b) lignite (c) bituminus (d) anthracite

80. Which of the following is used in the synthesis of polythene ?
(a) Methane (b) Ethene (c) Propane (d) Butane
[RAS/RTS (Pre) 2008,2009]

81. The process involved in the preparation of soap is called :
(a) Soapnification
(b) Water hydrolysis
(c) Freezing
(d) Polymerisation *[SSC CPO 2008]*

82. Which of the following is used in the commercial volcanization of the rubber ?
(a) Sulphur (b) Carbon (c) Phosphorus (d) Selenium
[CDS 2009]

83. Which one of the following is to be found in nail polish remover ?
(a) Acetone
(b) Benzene
(c) Petroleum ether
(d) Acetic acid *[CDS 2009]*

84. In which one of the following the maximum percentage of Nitrogen is to be found from the mass point of view ?
(a) Urea
(b) Ammonium Cyanide
(c) Ammonium Carbonate
(d) Ammonium Sulphate
[NDA 2009]

Which of the following is used as an antifreezing substance in the self starting engines ?
(a) Propyl alcohol (b) Ethanol
(c) Ethylene Glycole (d) Methanol *[UPPSC LS (Pre) 2009]*

Tetra Ethyl Lead (TEL) is :
(a) a catalyst in the combustion of fossil fuels
(b) an anti oxidant (c) an anti knocking compound
(d) a reducing agent *[SSC Graduate Level (Pre) 2010]*

Which one of the following is not the component of nucleon ?
(a) proton (b) neutron (c) electron (d) positron
[SSC Graduate Level (Pre) 2010]

88. Which one of the following metallic atom is present in the molecule of super phosphate ?
(a) Sodium (Na) (b) Potassium (K)
(c) Calcium (Ca) (d) Magnesium (Mg) *[NDA 2010]*

89. The element radium is extracted from :
(a) lime stone (b) pinch blend
(c) rettile (d) haematite *[39th BPSC (Pre) 1994]*

90. Galena is an ore of the metal :
(a) silver (b) lead (c) mercury (d) aluminium

91. Monozite is an ore of :
(a) Zarconium (b) Thorium (c) Titenium (d) Iron
[IAS (Pre) 1994]

92. The chemical formula of washing soda is :
(a) NaOH (b) $Ca(OH)_2$
(c) $NaOHCO_3$ (d) $Na_2CO_3 \cdot 10H_2O$ *[BPSC 1999]*

93. The metal which is more reactive than hydrogen is—
(a) mercury (b) copper (c) silver (d) tin
[NDA 2010]

94. The number of neutrons in $_{13}Al^{27}$ are :
(a) 40 (b) 27 (c) 14 (d) 13 *[NDA 2010]*

95. In the earth crust although the amount of aluminium is found to be more than iron, however aluminium is costly than iron; because
(a) aluminium is more useful than iron
(b) aluminium forms more alloys than iron
(c) aluminium made equipments are more acceptable then iron equipments
(d) the extraction processes of aluminium are more costly than extraction processes of iron *[NDA 1997]*

96. Which one of the following is not a periodic property (does not show any trend) on moving from one side to another in the periodic table ?
(a) Atomic size (b) Valency
(c) Radioactivity (d) Electronegativity *[CDS, 2010]*

97. Which one of the following statement is true regarding the aluminium :
(a) aluminium hydroxide is amphoteric in nature
(b) aluminium exists in the free state in nature
(c) nitric acid does not react with aluminium
(d) hot and conc. H_2SO_4 directly reacts with oxygen in which SO_2 gas is released *[CDS 2002]*

98. The chemical formula of plaster of peris is :
(a) $CaSO_4 \cdot 5H_2O$ (b) $2CaSO_4 \cdot H_2O$
(c) $(CaSO_4)_2 \cdot 2H_2O$ (d) $CaSO_4 \cdot MgO$ [BPSC (Pre) 1998]

99. The chemical name of lime stone is :
(a) Calcium chloride (b) Calcium oxide
(c) Calcium carbonate (d) Calcium sulphate [UPPCS 1991]

100. Which one of the following is a transition metal ?
(a) Aluminium (b) Manganese (c) Magnesium (d) Calcium
[NDA 2010]

101. On rusting in the iron :
(a) its wt. is increased (b) its wt. is decreased
(c) no changes take place (d) its wt. changes [MPPCS 1991]

102. Which one of the following element is mixed up in making steel which can resist high temperature and which has high level hardness :
(a) aluminium (b) chromium (c) nickel (d) tungsten

103. Human stomach produces acid 'X' which helps in digestion of food. Acid 'X' is—
(a) Acetic acid (b) Methanoic acid
(c) Hydrochloric acid (d) citric acid
[NDA, 2011]

104. Blue Vitriol is :
(a) Copper sulphate (b) Calcium sulphate
(c) Iron sulphate (d) Sodium sulphate [UPPCS 1990]

105. A bee-sting leaves an acid which causes pain and irritation. The injected acid is—
(a) Acetic acid (b) Sulphuric acid
(c) Citric acid (d) Methanoic acid
[NDA, 2011]

106. The strong smell of a substance which is used in the colouration or painting is :
(a) CaOH (b) $Al_2(SO_4)_3$ (c) $CaCO_3$ (d) $Zn_3(PO_4)_2$

107. Which one of the following metal is the best conductor of electricity ?
(a) Gold (b) Silver (c) Copper (d) Zinc

108. The substance which is frequently used in the photography is :
(a) Silver Nitrate (b) Silver bromide
(c) Sulphuric acid (d) Citric acid [UPPCS (Pre) 1992]

109. Which one of the following metal is the heaviest ?
(a) Silver (b) Copper (c) Gold (d) Lead
[CDS 1999]

110. Which of the following metal is found to be as a liquid at ordinary temperature :
(a) Lead (b) Mercury (c) Nickel (d) Tin
[BPSC 2001]

111. The chemical substances frequently used in the fluorescent tube are :
(a) sodium oxide and argon (b) sodium vapour and neon
(c) mercury vapour and argan (d) mercury oxide and argon
[CSIR 2004]

112. Which one of the following metal is used in the accumulator cell ?
(a) copper (b) lead (c) aluminium (d) zinc

113. Which of the following metal is the hardest one ?
(a) Gold (b) Iron (c) Platinum (d) Lead

114. The gas originating in paddy field is :
(a) ethane (b) methane
(c) nitrogen (d) All of these *[UPPCS (Pre) 2006]*

115. Which one of the following is the heaviest metal ?
(a) Copper (b) Uranium (c) Aluminium (d) Silver
[44th BPSC (Pre) 2001]

116. The colours of the fire crackers are extracted from the elements of the salt of :
(a) Zn and S (b) K and Hg (c) Sr and Ba (d) Cr and Ni
[IAS (Pre) 2004]

117. The density of the water in maximum at :
(a) 100°C (b) + 4°C (c) 0°C (d) – 4°C
[42nd BPSC (Pre) 1998]

118. The boiling and freezing point of water on mixing an edible salt :
(a) increases (b) decreases
(c) firstly increases and then decreases
(d) firstly decreases and then increases *[NDA 1999]*

119. The permanent hardness of water appears due to :
(a) carbonates of calcium and magnesium
(b) bicarbonates of calcium and magnesium
(c) chloride and sulphate of calcium and magnesium
(d) None of these *[40th BPSC (Pre) 1995]*

120. The heavy water is a type of :
(a) coolent (b) moderator (c) ore (d) fuel
[UPPCS (Pre) 1993]

121. In all biological compounds the most fundamental element is :
(a) nitrogen (b) oxygen (c) carbon (d) sulphur
[UPPCS (Pre) 2003]

122. In which of the following carbon is not present ?
(a) diamond (b) graphite (c) coal (d) None of these
[42nd BPSC (Pre) 1998]

123. Which one of the following can replace hydrogen from the acids and forms salt ?
(a) Sulphur (S) (b) Silicon (Si)
(c) Zinc (Zn) (d) Phosphorus (P) *[NDA 2010]*

124. The percentage content of carbon is found to be maximum in :
(a) bituminous (b) lignite (c) peat (d) anthracite
[UPPCS (Pre) 1999]

125. The ordinary and general type of coke is :
(a) anthracite (b) lignite (c) bituminous (d) peat
[39th BPSC (Pre) 1994]

126. The polluted gas emitted from the vehicles is mainly :
(a) Carbondioxide (b) Carbon monoxide *[BPSC 2001]*
(c) Marsh gas (d) Nitrogen oxide

127. Which one of following sets of elements was primarily responsible for the origin of life on the Earth ?
(a) Hydrogen, Oxygen, Sodium (b) Carbon, Hydrogen, Nitrogen
(c) Oxygen, Calcium, Phosphorus *[C-SAT, 2012]*
(d) Carbon, Hydrogen, Potassium

128. Dry ice is :
(a) Solid water (b) Solid CO_2
(c) Dehydrated ice (d) Solid H_2O_2

129. Quartz is composed of :
(a) Calcium sulphate (b) Calcium silicate
(c) Sodium sulphate (d) Sodium silicate *[SSC Grad. 2004]*

130. The chemical substance which is easily soluble in water is
(a) carbon (b) nitrogen (c) ammonia (d) iodine
[UPPCS (Pre) 1993]

131. Before X-ray examination (coloured X-ray) of the stomach, pateints are given suitable salt of barium because—
(a) Barium salts are white in colour and this helps stomach to appear clearly
(b) Barium is a good absorber of X-rays and helps stomach to appear clearly
(c) Barium salts are easily available
(d) Barium allows X-rays to pass through the stomach *[CDS, 2012]*

132. Tear gas is :
(a) hydrogen sulphide (b) chlorine
(c) hydrogen chloride (d) ammonia *[Uttarakhand PCS 2003]*

133. The most abundantly occurring element in the earth-crust is :
(a) oxygen (b) nitrogen (c) manganese (d) silicon
[BPSC (Pre) 1998]

134. Which one among the following polymers is used for making bullet proof material ?
(a) Polyvinyl Chloride (b) Polystyrene
(c) Polyethylene (d) Polyamide *[CDS, 2012]*

135. Oxygen and Ozone are :
(a) allotropes (b) isotopes (c) isomers (d) isobars
[CDS 2002]

136. Which one of the following is not a mixture ?
(a) Toothpaste (b) Toilet soap (c) Baking soda (d) Vinegar
[CDS, 2010]

137. Which one of the following is the correct sequence of the reactivity order of the elements ?
(a) Cu > Mg > Zn > Na (b) Na > Zn > Mg > Cu
(c) Cu > Zn > Mg > Na (d) Na > Mg > Zn > Cu *[NDA 2010]*

138. Which of the following is assumed to be the most fundamental chemical in the chemical industry ?
(a) H_2CO_3 (b) HNO_3 (c) H_2SO_4 (d) HCl
[BPSC (Pre) 1999]

139. The electrolyte used in the car battery is :
(a) hydrochloric acid (b) sulphuric acid
(c) nitric acid (d) distil water *[BPSC (Pre) 1998]*

140. Which of the following is obtained in its pure form by the reaction of sugar and sulphuric acid ?
(a) water (b) carbon (c) oxygen (d) hydrogen
[NDA 2004]

141.Which of the following is most reactive among the halogens ?
(a) fluorine (b) chlorine (c) bromine (d) iodine
[IAS (Pre) 1997]

142.Which of the following noble gas doesn't exist in air ?
(a) helium (b) neon (c) argon (d) redon
[BPSC (Pre) 2004]

143.Who discovered inert gases ?
(a) Pristle (b) Ramse (c) Shilley (d) Cauvendish

144.The gas used to fill up the tyres of the aircraft is :
(a) hydrogen (b) helium (c) nitrogen (d) neon

145.Which of the following gas is used to fill up the balloon, specially when weather related prediction and reporting is to be done ?
(a) O_2 (b) CO_2 (c) CH_4 (d) He

146.The gases used in the respiratory activities of sailors (divers) are :
(a) oxygen and nitrogen (b) oxygen and helium
(c) oxygen and argon (d) oxygen and neon

147.The gas used for the light decoration and advertisement in the exposure tubules is :
(a) CO_2 (b) NH_3 (c) SO_2 (d) Ne

148.The inert gas found most abundantly in our atmosphere is :
(a) He (b) Ne (c) Ar (d) Kr

149.The chemist who propounded the vital force theory of the power of life is :
(a) Berzealus (b) Wholer (c) Kolbe (d) Berthlot

150.The fristly synthesized organic compound in the laboratory is :
(a) formic acid (b) acetic acid (c) urea (d) methane

151.The four valencies of carbon atom are directed around the tetrahedral edges and carbon is confined at the centre in the organic compounds, this idea was firstly conceived by :
(a) J. J. Thomson (b) Albert Einsten
(c) Michael Faraday (d) Level & Wanthoff

152.The most abundantly found organic compound in the nature is :
(a) glucose (b) fructose (c) sucrose (d) cellulose

153.The process through which camphor is purified :
(a) sublimation (b) distillation
(c) chromatography (d) vacuum distillation

154.Which of the following substance is used in the form of solder in the soldering process ?
(a) Aluminium and Iron (b) Lead and Tin
(c) Aluminium and Lead (d) Iron and Tin [IAS (Pre) 2006]

155.The difference appears in the molecular formula of every adjacent homologous member of series :
(a) CH_2 (b) CH_4 (c) C_2H_4 (d) C_2H_6

156.Which of the following is obtained by the fractional distillation of the wood :
(a) acetic acid (b) sulphuric acid
(c) pyrolegneous acid (d) formic acid

157. The organic compounds whose molecular formula are same but structural formula are different, are called :
(a) isotopes (b) isobars (c) homologous (d) allotropes

158. The normal butane and iso butane are :
(a) optical isomer (b) chain isomer
(c) positional isomer (d) functional isomer

159. The petrol which is used in the motor vehicles is basically the mixture of [CDS 2002]
(a) alcohols (b) carbohydrates
(c) hydrocarbons (d) hydrocarbons and alcohols

160. The process through which various components of a petroleum substance are separated is called :
(a) destructive distillation (b) ordinary distillation
(c) fractional distillation (d) vacuum distillation

161. Which one among the following can produce light by a chemical change?
(a) Sun (b) Moon
(c) Electric bulb (d) Lighting and thunder [CDS 2010]

162. Which of the following is also known by the name of liquid gold :
(a) petroleum (b) platinum (c) aquaregia (d) pyrine

163. Which among the following are the most important raw materials for the manufacturing of soap ?
(a) Fats and Caustic Alkali (b) Fats and Potash
(c) Vegetable oil and Potash (d) Fats and Acid [CDS, 2010]

164. Gashol which is used as a fuel in the motor vehicles is a mixture of :
(a) methane and alcohol (b) petrol and alcohol
(c) hydrogen and alcohol (d) natural gas and alcohol

165. In heavy vehicles diesel is used as a fuel because :
(a) it has more mileage and safe for the engine
(b) it is less costly and useful in fuel savings
(c) it has high power and convenient
(d) it is cheaper with comparison to the petrol [UPPCS (Pre) 1992]

166. The molecular formula of the compound whose emprical formula is CH_2O and molecular wt. is 60 is :
(a) C_2H_4O (b) $C_2H_4O_2$ (c) CH_4O (d) CH_4O_2

167. The chemical susbtance used in the manufacturing of synthetic blanket, sweater etc. on the behalf of wool is—
(a) Nylon (b) Teflon (c) Orion (d) Bakelite [CDS 2010]

168. The chemical susbtance used in the car engine to prevent it from knocking is—
(a) ethyl alcohol (b) butane
(c) lead tetraethyl (d) white petrol [UPPCS (Pre) 1998]

169. The qualitative diagonestic of Gasoline is detected by :
(a) iodine value (b) ceiten number
(c) octane number (d) mass density [CDS 2002]

170. The spmerty wax is extracted from the :
(a) palm leaves (b) roofs of honey
(c) petroleum (d) whale

171. The vaseline is extracted from the :
(a) plant gum (b) coaltar (c) Pern wax (d) petroleum

[SSC Mat 2000]

172. The paraffin is a bye-product of the :
(a) petroleum refining
(b) resources of the agricultural residues
(c) honey culturing industry (d) leather industry

173. The shape of the methane molecule is :
(a) angular (b) coplanar (c) linear (d) tetrahedral

174. The gas produces through the reaction of aluminium carbide and water is :
(a) methane (b) ethane (c) ethylene (d) acetylene

175. The gas which is also known as Marsh Gas is :
(a) methane (b) ethane (c) ethylene (d) acetylene

176. The gas releases through the septic tank is :
(a) methane (b) ammonia (c) hydrogen (d) nitrogen

[CDS 1999]

177. The main component of Gober Gas is :
(a) chlorine (b) hydrogen (c) ethylene (d) methane

178. The main component of Natural Gas is :
(a) methane (b) ethane (c) butane (d) hydrogen

179. The main component of Bio Gas is :
(a) methane (b) ethane (c) propane (d) butane

180. The large source of methane in India is :
(a) the field of paddy (b) the field of wheat
(c) the field of sugarcane (d) the garden of the fruits

181. Almost all explosion occurs in the mines by :
(a) the mixture of nitrogen with oxygen
(b) the mixture of acetylene with oxygen
(c) the mixture of air with methane
(d) the mixture of CO_2 with ethane

[IAS (Pre) 2000]

182. The main components of the LPG are :
(a) methane, ethane and hexane (b) methane, ethane and nonane
(c) methane, propane and butane (d) ethane, butane and hexane

183. Which of the following chemical substance is mixed up in the LPG for the safety point of view so that during leakage it can be easily detected
(a) Glycol (b) Glyceral (c) Mercapton (d) Alcohol

184. The refrigerant freon is :
(a) calcium fluoride (b) a type of flusper
(c) hydro fluoric acid (d) dichloro difluro methane

185. Which of the following gas is used in the cigarette lighter :
(a) butane (b) methane (c) propane (d) redon

[RRB ASM/GG 2005]

186. The plastic obtained from the polymerisation of ethylene is :
(a) Teflon (b) Bakelite (c) Nylone (d) Poly ethylene

187. The poisoness gas emerged through the reaction of ethylene and sulphur monochloride is :
(a) lewsite (b) mustard gas (c) chloropicrin (d) serin

188. During first world war which of the following gas was used as a chemical weapon ?
(a) carbon monoxide (b) hydrogen cynide
(c) mustard gas (d) burning vapour [IAS (Pre) 1997]

189. Which of the following gas is produced through pouring (passing) the water on calcium carbide ?
(a) methane (b) ethane (c) ethylene (d) acetylene
[RRB ASM/GG 2005]

190. The gas used in the weldings of the metallic joints is :
(a) ethylene (b) acetylene (c) propylene (d) methane

191. Which one among the following is a source of methane emission into the atmosphere ?
(a) Automobile exhaust fume (b) Industrial chimney
(c) Mining (d) Wetland [CDS, 2012]

192. The toxic gas lewisite used in the war is prepared by :
(a) chlorine (b) ammonia (c) acetylene (d) nitrobenzene

193. The element which has maximum number of isotopes is :
(a) Bismuth (b) Nickel (c) Lead (d) Polonium

194. Which of the following chemically predominants in the silk fibres ?
(a) Protein (b) Carbohydrate
(c) Complex lipid
(d) Mixture of polysaccharide and fat [CDS, 2010]

195. The chloroform is kept in the coloured bottle (container) because it directly reacts with air and light and forms a toxic substance which is:
(a) phosphin (b) phosgene (c) mustard gas (d) CO

196. The carbon tetrachloride is also known as :
(a) marsh gas (b) mustard gas (c) pyrin (d) pyrole

197. The fire extinguisher used in the electric firing is :
(a) pyrin extinguisher (b) foam (leather) extinguisher
(c) water extinguisher (d) soda acid extinguisher

198. Which of the following is also known as wood spirit :
(a) methyl alcohol (b) ethyl alcohol
(c) ethylene glycol (d) glycerol

199. The antifreezer is a mixture of :
(a) acetic acid and water (b) formic acid and water
(c) methyl alcohol and water (d) ethyl alcohol and water

200. The excess use of ethyl alcohol damages the human organ which is :
(a) kidney (b) liver (c) heart (d) intestine

201. In the hooch tragedy (casualty occurring due to wine poisoning) sometimes the incidents of blindness is caused by the poisoness substance :
(a) ethyl alcohol (b) methyl alcohol
(c) amyle alcohol (d) benzyle alcohol

202. The micro-nutrients provided by inorganic fertilizers are—
(a) Carbon, iron and boron
(b) Magnesium, manganese and sulphur
(c) Magnesium, jinc and iron
(d) Nitrogen, phosphorus and potassium [CDS, 2012]

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203. Which one among the following is correct regarding ^{20}Ne, $^{23}\text{Na}^{+}$, $^{19}\text{F}^{-}$ and $^{24}\text{Mg}^{2+}$?
(a) They are isomers of each other
(b) They are isotopes of each other
(c) They are isoelectronic with each other
(d) All of the above

204. The end product of an alcoholic fermentation is : *[NDA, 2012]*
(a) pyrubic acid (b) acetaldehyde (c) ethyl alcohol (d) formic acid

205. The Gasohol is a mixture of gasoline and :
(a) ethyl alcohol (b) methyl alcohol
(c) butyl alcohol (d) ethylene glycol

206. The methanol is also known by the name of :
(a) rubing alcohol (b) deformed alcohol
(c) wood alcohol (d) grain alcohol *[RRB ASM 2004]*

207. Which one among the following is the main ingredient in cement ?
(a) Gypsum (b) Limestone (c) Clay (d) Ash
[NDA, 2011]

208. Glass is actually—
(a) A crystalline solid (b) An ionic solid
(c) An elastic solid (d) A nitrified liquid *[NDA, 2011]*

209. The mixture of antifreezer substances are used in the radiators of automobiles of cold countries, this mixture has :
(a) water and ethyl alcohol (b) water and glyceral
(c) water and ethylene glycol (d) None of these

210. The aqueous solution of 40% formaldehyde is called :
(a) ethylene (b) acetylene (c) pyrin (d) formlin

211. The medicine urotropin used in the urinal diseases is prepared from :
(a) chloroform (b) nitrobenzene
(c) acetic acid (d) formaldehyde

212. The medicine chlorotone used to keep the mental balance of the sailor (diver) or mountainers is basically extracted from :
(a) acetic acid (b) acetaldehyde
(c) formaldehyde (d) acetone

213. If a piece of limestone is dipped inside the water of a jar (container) then some bubbles are appeard, which are caused by—
(a) Hydrogen (b) Oxygen
(c) Water vapour (d) Carbon dioxide *[CDS, 2010]*

214. Which of the following acid is to be found in the vinegar ?
(a) hydrochloric acid (b) citric acid
(c) oxallic acid (d) acetic acid *[BPSC (Pre) 1998]*

215. The molasses (sugar gravey) is an excellent example of :
(a) acetic acid (b) glycerine (c) power alcohol (d) urea
[Uttarakhand PCS (Pre) 2003]

216. Which of the following is to be found in the tomato sauce ?
(a) citric acid (b) oxallic acid (c) lactic acid (d) acetic acid

217. The vinegar is a solution of :
(a) 5% acetic acid in water (b) 25% acetic acid in water
(c) 50% acetic acid in water (d) 40% acetic acid in water
[RRB ASM/GG 2004]

218. The accumulation of which of the following causes muscle fatigue in the human body :

(a) pyrubic acid (b) lactic acid
(c) oxale acetic acid (d) uric acid *[CSIR 2004]*

219. Which of the following acid is utilized in the photography ?

(a) formic acid (b) oxallic acid
(c) citric acid (d) acetic acid *[UPPCS (Pre) 2003]*

220. Itching due to insect bite is caused by—

(a) Formic acid (b) Acetic acid
(c) Lactic acid (d) Maleic acid *[CDS, 2010]*

221. Which of the following is chemical formula of urea :

(a) NH_4Cl (b) NH_2CONH_4 (c) NH_2CONH_2 (d) NH_3

222. In urea, nitrogen is to be found in the form of :

(a) nitrate (b) nitrite (c) ammonium (d) amide

223. The percentage amount of nitrogen present in urea is :

(a) 26% (b) 36% (c) 46% (d) 60%

224. The first synthesis of urea in the laboratory was done by :

(a) Williamson (b) Kolbe (c) Wohler (d) Bertholet

225. A woman intends a chemical wash of her ornaments without any quantity loss, then which of the following chemicals will be suitable for the wash ?

(a) aquaregia (b) conc H_2SO_4
(c) conc NaOH (d) solution of NaS_2O_7 *[NDA 2010]*

226. Which of the following is used in Dry Cleaning :

(a) benzene (b) nitrobenzene
(c) chlorobenzene (d) hydroxic benzene

227. Which of the following is obtained by the reaction of benzene and chlorine in the presence of a catalyst ?

(a) benzene hexachloride (b) benzyle chloride
(c) chloro benzene (d) benzoyl chloride *[CDS 2002]*

228. Trinitro Toluene (TNT) is a/an :

(a) pesticide (b) insecticide (c) explosive (d) germicide

229. The oil of Mirbane is also known by the name of :

(a) nitro benzene (b) aniline (c) phenol (d) toluene

230. The chemical name of tear gas is :

(a) acetophenon (b) benzophenon
(c) α-bromo acetophenon (d) α-chloro acetophenon

231. Which of the following substance is employed to examine the adulteration of the foodstuffs ?

(a) citric acid (b) potassium chloride
(c) sodium benzoyate (d) sodium chloride

232. Which one of the following reducing agents can also act as an oxidizing agents ?

(a) H_2 (b) H_2S (c) SO_2 (d) HI *[CDS, 2010]*

233. The chemical formula of carbolic acid is :

(a) H_2CO_3 (b) C_6H_5COOH (c) C_6H_5OH (d) $C_6H_5CH_2OH$

234. The natural rubber is a polymer of :
(a) ethylene (b) acetylene
(c) vinyl chloride (d) isoprin

235. Which of the following is not a natural polymer ? [UPPCS (Pre) 1992]
(a) wool (b) silk (c) leather (d) nylone

236. Which of the following is a polymer :
(a) vinyl chloride (b) urea (c) starch (d) styrine

237. A milkman puts banana leaf in the milk jar, because banana leaf—
(a) gives a fresh flavour to the milk
(b) makes the milk acidic and resistant to yeast
(c) makes the milk basic and resistant to yeast
(d) increases the whiteness of the milk

[CDS, 2010]

238. By the polymerisation of which of the following teflon plastic is prepared :
(a) ethylene (b) acetylene
(c) benzene (d) tetrafluoro ethylene

239. The cabinets of telephone receiver, radio and television are made from
(a) teflon (b) bakelite (c) vitol (d) gleptol

240. The plastic used in the preparation of non-sticky utensils is :
(a) backelite (b) lac (c) vitol (d) teflon

241. The first man made (artificial) silk is :
(a) reyon (b) nylon (c) polyster (d) tericot

[RRB ASM/GG 2003]

242. Which one of the following is not biodegradable ?
(a) Woollen mat (b) Silver Foil
(c) Leather bag (d) Jute basket

[CDS, 2010]

243. Nylon is a :
(a) vinyl polymer (b) poly amide
(c) polyster (d) poly sacchride

244. Which of the following is not an explosive ?
(a) TNT (b) TNG
(c) Cyclo trimethylene trinitrotremin
(d) Nitro chloroform

[UPPCS (Pre) 2001]

245. Which of the following is called Noble's oil ?
(a) Trinitro Glycerine (TNG) (b) Trinitro Phenol
(c) TNT (d) Nitro Glycerine

246. The explosive nitroglycerine is a :
(a) salt (b) nitro hydrocarbon
(c) complex hydrocarbon (d) ester [BPSC 2004, IAS (Pre) 2009]

247. RDX is :
(a) Recently Developed Explosive (b) Research Developed Explosive
(c) Really Descent Explosive (d) Rectified Developed Explosive

248. Who was the inventor of dynamite ?
(a) Otto Han (b) Rutherford (c) Edison (d) Alferd Nobel

249. The main component of dynamite is :
(a) TNT (b) Tri Nitro Phenol
(c) Nitro Glycerine (d) Nitro Benzene

250. Aspirin is a/an :
(a) antibody (b) antipyratic (c) moderate (d) None of these

251. The detergent is a :
(a) soap (b) drug (c) catalyst
(d) highly fatty acids of oil

252. The raw material used for the manufacturing of Nylon is— [BPSC 2004]
(a) ethyline (b) edipic acid
(c) urea (d) formaldehyde

253. The water hydrolysis of oil by the alkalies is called : [CDS, 2010]
(a) esterification (b) polymerisation (c) soapification (d) acetylisation

254. Which of the following chronological order of the density of various substances is true ?
(a) steel > mercury > gold (b) gold > mercury > steel
(c) steel > gold > mercury (d) gold > steel > mercury [IAS 2005]

255. The liquid used in making dynamite is :
(a) Nitro Glycerine (b) Olic acid
(c) Lactic acid (d) Malleoic acid

Answers

1. (c) 2. (c) 3. (b) 4. (a) 5. (b) 6. (a) 7. (c) 8. (c)
9. (b) 10. (b) 11. (d) 12. (a) 13. (a) 14. (c) 15. (a) 16. (b)
17. (b) 18. (a) 19. (c) 20. (c) 21. (a) 22. (d) 23. (c) 24. (a)
25. (d) 26. (a) 27. (c) 28. (a) 29. (c) 30. (b) 31. (c) 32. (a)
33. (b) 34. (a) 35. (b) 36. (a) 37. (d) 38. (a) 39. (b) 40. (a)
41. (c) 42. (d) 43. (a) 44. (a) 45. (a) 46. (a) 47. (b) 48. (c)
49. (d) 50. (b) 51. (b) 52. (b) 53. (c) 54. (a) 55. (c) 56. (c)
57. (d) 58. (b) 59. (a) 60. (a) 61. (b) 62. (b) 63. (b) 64. (d)
65. (a) 66. (c) 67. (b) 68. (d) 69. (b) 70. (d) 71. (a) 72. (b)
73. (c) 74. (a) 75. (d) 76. (a) 77. (c) 78. (a) 79. (b) 80. (b)
81. (a) 82. (a) 83. (a) 84. (a) 85. (c) 86. (c) 87. (c) 88. (c)
89. (b) 90. (b) 91. (b) 92. (d) 93. (d) 94. (c) 95. (d) 96. (c)
97. (b) 98. (b) 99. (c) 100. (b) 101. (a) 102. (b) 103. (c) 104. (a)
105. (a) 106. (d) 107. (b) 108. (b) 109. (c) 110. (b) 111. (c) 112. (b)
113. (c) 114. (b) 115. (b) 116. (c) 117. (b) 118. (c) 119. (c) 120. (b)
121. (c) 122. (d) 123. (c) 124. (d) 125. (c) 126. (b) 127. (a) 128. (b)
129. (b) 130. (c) 131. (b) 132. (b) 133. (a) 134. (b) 135. (a) 136. (c)
137. (b) 138. (c) 139. (b) 140. (b) 141. (a) 142. (c) 143. (b) 144. (b)
145. (d) 146. (b) 147. (d) 148. (c) 149. (a) 150. (c) 151. (d) 152. (d)
153. (a) 154. (b) 155. (a) 156. (c) 157. (c) 158. (b) 159. (c) 160. (c)
161. (d) 162. (a) 163. (b) 164. (b) 165. (c) 166. (b) 167. (d) 168. (c)
169. (c) 170. (d) 171. (d) 172. (a) 173. (d) 174. (a) 175. (a) 176. (a)
177. (d) 178. (a) 179. (a) 180. (a) 181. (c) 182. (c) 183. (c) 184. (d)
185. (b) 186. (d) 187. (b) 188. (c) 189. (d) 190. (b) 191. (d) 192. (c)
193. (d) 194. (d) 195. (b) 196. (c) 197. (a) 198. (a) 199. (d) 200. (b)
201. (b) 202. (d) 203. (b) 204. (c) 205. (a) 206. (c) 207. (b) 208. (a)
209. (c) 210. (d) 211. (d) 212. (d) 213. (d) 214. (d) 215. (a) 216. (d)
217. (a) 218. (b) 219. (b) 220. (b) 221. (c) 222. (d) 223. (c) 224. (c)
225. (d) 226. (a) 227. (c) 228. (c) 229. (a) 230. (d) 231. (c) 232. (c)
233. (c) 234. (d) 235. (d) 236. (c) 237. (c) 238. (d) 239. (b) 240. (d)
241. (b) 242. (b) 243. (b) 244. (d) 245. (a) 246. (d) 247. (b) 248. (d)
249. (c) 250. (b) 251. (d) 252. (b) 253. (c) 254. (b) 255. (a)

★★★

C. Inventions related to the Medical/Biological Science

Associated terms	Inventors	Associated terms	Inventors
Vitamin	Hopkins	DNA	Watson & Crick
Antigen	Ladstinar	Insulin	Bating & West
Polio vaccine	J. E. Shalk	Heart transplantation	Christan Benard
Kidney machine	Cholf	Parasitic malaria	Ronoald Ross
Straptomycine	Vaxman	Anti-pregnancy pills	Pincuss
Stethescope	Rene Linek	BCG	Urin Cholmat
TB Bacteria	Robert Koach	Bacteria	Leeuwen hock
Homeopath	Haniman	Open Heart Surgery	Walton Lilehock
DDT	Pol Muller	Blood circulation	William Harbe
Bacteria of leprosy	Henson	Vaccination	Adberd Gener
Penicillin	A Flemming	Polio drop	Albert Sebine
Inoculation of small pox	Adberd Genar	Genetic code	Hargobind Khorana
RNA	Watson & Arther	First test tube baby	Adberds & Stepto
Microbes of malaria	Charles Laweran	Rh factor, blood replacement	Charles Landstiner
Gene of cancer	Robert Winberge	Chloroform	Harison & Simpson

Objective Questions

1. The vitamin(s), which is/are generally excreted in urine, is/are
   (a) vitamin A (b) vitamin B
   (c) vitamin C (d) vitamins D and K *[CDS, 2010]*

2. Which one among the following is a major source of sugar ?
   (a) Watermelon (b) Beetroot
   (c) Sugarcane (d) Date *[CDS, 2010]*

3. Consider the following :
   1. Photosynthesis 2. Respiration
   3. Decay of organic matter 4. Volcani action
   Which of the above add carbon dioxide to the carbon cycle on Earth ?
   (a) 1 and 4 only (b) 2 and 3 only
   (c) 2, 3 and 4 only (d) 1, 2, 3 and 4
   [CSAT -IAS 2011]

4. The study of Dendrology is associated with :
   (a) flowers (b) trees (c) Shrubs (d) plants

5. The study of flowers is called :
   (a) Anthology (b) Agrestology (c) Phynology (d) Polinology

⑥ Itching due to insect bite is caused by
   (a) formic acid (b) acetic acid
   (c) lactic acid (d) maleic acid *[CDS, 2010]*

7. Regular intake of fresh fruits and vegetables are recommended in the diet since they are a good source of antioxidants. How do antioxidants help a person in order to maintain the health and promoting congevity ?
   (a) They activate the enzymes necessary for vitamin synthesis in the body and help in order to prevent the vitamin deficiency
   (b) They prevent excessive oxidation of carbohydrates, fats and proteins in the body and help in order to avoid the unnecessary wastage of energy
   (c) They neutralize the free radicals produced in the body during metabolism
   (d) They activate certain genes in the cells of the body and help in delay the ageing process *[CSAT-IAS 2011]*

8. Biodiversity forms the bases for human existence in the following ways :
   1. Soil formation 2. Prevention of soil erosion
   3. Recycling of waste 4. Pollination of crops

   Select the correct answer using the codes given below;
   (a) 1, 2 and 3 only (b) 2, 3 and 4 only
   (c) 1 and 4 only (d) 1, 2, 3 and 4 *[CSAT-IAS 2011]*

9. The study of Annual rings is called :
   (a) dendrology (b) dendrochronology
   (c) agronomy (d) horticulture

10. The study of fruits is called :
    (a) spermology (b) anthology (c) pedology (d) pomology

11. The study of internal structure of the plants is called :
    (a) morphology (b) taxonomy (c) anatomy (d) histology

12. If excess fertilizer is applied to a plant without water, the plant will
    (a) be stunted in growth (b) develop modifications
    (c) die due to plasmolysis (d) remain unaffected *[CDS, 2010]*

13. Tips of leaves in grasses and common garden plants show water drops in early morning hours. This water accumulation is obtained from
    (a) atmosphere (b) stomata
    (c) vascular bundles (d) hydathodes *[CDS, 2010]*

14. When the bark of a tree is removed in a circular fashion all around near its base, it gradually dries up and dies because :
    (a) water from soil cannot rise to aerial parts
    (b) roots are starved of energy
    (c) tree is infected by soil microbes
    (d) roots do not receive oxygen for respiration *[CSAT -IAS 2011]*

15. Which one among the following animal tissues transports hormones and heat and maintains water balance ?
    (a) Connective tissue (b) Muscular tissue
    (c) Blood (d) Nervous tissue *[CDS, 2010]*

16. Which one among the following plants cannot be multiplied by cuttings ?
    (a) Rose (b) Bryophyllum
    (c) Banana (d) Marigold *[CDS, 2010]*

17. Cattle are capable of digesting cellulose present in the grass and/or fodder that they eat. This ability is attributed to the
(a) presence of cellulose degrading bacteria in the rumen
(b) production of cellulose by the cattle rumen
(c) acids present in the rumen
(d) prolonged retention of cellulose in the rumen

18. Why are pregnant women recommended substantial intake of green leafy vegetables in their diet, especially in the 1st trimester ? [CDS, 2010]
(a) They are a rich source of chlorophyll
(b) They are a rich source of lecithin
(c) They are a rich source of folic acid which is required for DNA synthesis
(d) They are a rich source of essential fatty acids required for cell anabolism

19. The flowers plants have been kept under : [CDS, 2010]
(a) creptogams (b) phanrogams (c) bryophytes (d) tredophytes

20. The non-flowers plants have been kept under :
(a) creptogams (b) phanrogams (c) bryophytes (d) tredophytes

21. As usual shape of bacteria is :
(a) rod shaped (b) round (c) spiral (d) comatic

22. Who was the inventor of bacteria ?
(a) Leeuwenhock (b) Robert Hooke
(c) Robert Koach (d) Louis Pasteur

23. Human body's main organ of balance is located in
(a) inner part of ear (b) top part of vertebral column
(c) front part of brain (d) middle [CDS, 2010]

24. The bacteria which is found to be in the human intestine is :
(a) corinobactireum (b) ashrrishia colie
(c) bibreo coleri (d) Basils anthresis

25. The food poisoning is caused by :
(a) clostrideam titeni (b) clostrideam boutulium
(c) salmonela toyphosis (d) Baslils anthresis

26. Plants which grow on saline soils are
(a) xerophytes (b) hydrophytes
(c) halophytes (d) succulents [BPSC (Pre) 2011]

27. A deficiency of which one of the following minerals is most likely to lead to an immunodeficiency ?
(a) Calcium (b) Zinc
(c) Lead (d) Copper [CDS, 2010]

28. Which among the following is the correct increasing order of pH found in human body ?
(a) Gastric juice, saliva, blood (b) Blood, saliva, gastric juice
(c) Saliva, blood, gastric juice (d) Gastric Juice, blood, saliva [CDS, 2010]

29. Mosquito can be a vector for following diseases except
(a) Yellow fever (b) Dengue fever [CDS, 2010]
(c) Filaria (d) Kala-azar

30. Which part of brain controls fine movement, mantains balance and equilibrium of the body and muscle tone in a human being ?
(a) Cerebrum (b) Thalamus
(c) Cerebellum (d) Hypothalamus [NDA, 2010]

31. The cooling process of the substance having microbes implies that :
(a) to contract protoplasm of the microbes
(b) to diminish growth rate of the microbes
(c) to make inactive the microbes
(d) to destroy the microbes

32. Environment is a composite state of : [RRB TC/CC 2002]
(a) biotic factors (b) physiographic factors
(c) abiotic factors (d) all of the above [BPSC 2011]

33. The milk is transformed into the curd; by—
(a) micobacterium (b) staphylococus
(c) lactobacillus (d) yeast [SSC Graduate 2002]

34. The bacteria which does the work of nitrogen fixatioin in the legumeneous plants is :
(a) Azetovector (b) Nitrovector
(c) Rizhobium (d) Sudomonas

35. Which component of plants receives stemulus for flowering ?
(a) stems (b) branches (c) leaves (d) roots
[BPSC (Pre) 2011]

36. The virus is assumed to be a—
(a) living substance (b) non-living substance
(c) transitional group between a living and non-living organism
(d) living organism which has lost its power of senses

37. Development of the natural systems is described as ?
(a) function of the systems (b) evolution of the systems
(c) self-sustained process of the systems
(d) none of the above

38. The disease hydrophobia is caused by—
(a) bacteria (b) fungi (c) virus (d) protozoa

39. Edberd Gener had invented :
(a) inoculation of tuberclosis (b) inoculation of AIDS
(c) inoculation of polio (d) inoculation of smallpox

AIDS is caused by :
(a) lack of T–4 lymphocytes (b) high blood pressure
(c) lack of riboflobin (d) bacterial infection

1. The saliva hydrolyses starch into—
(a) glucose (b) sucrose (c) fructose (d) CO_2 & H_2O

2. Leishmania the causative agent of Kala-azar, multiplies asexually by
(a) budding (b) binary fission
(c) multiple fission (d) sporogony [NDA, 2010]

3. Genetics deals with :
(a) Mendel's laws (b) Organic evolution
(c) DNA structure (d) Heredity and variations
[BPSC (Pre) 2011]

44. Mendel's principles of inheritance are based on :
(a) vegetative reproduction
(b) asexual reproduction
(c) sexual reproduction
(d) all of the above

45. The virus is : *[BPSC 2011]*
(a) protein and lipid
(b) nucleic acid and protein
(c) lipid and carbohydrate
(d) carbohydrate

46. Chemically silk fibres are predominantly *[SSC Grad. 2002]*
(a) Protein
(b) Carbohydrate
(c) Complex lipid
(d) Mixture of polysaccharide and fat

47. Administering a vaccine provides protection by inducing synthesis of antibodies (proteins) specific to the vaccine. The cell in the body responsible for the production of antibodies is *[CDS, 2010]*
(a) granulocyte
(b) lymphocyte
(c) erythrocyte (red blood cell)
(d) platelet

48. Which of the following is a viral disease ? *[NDA, 2010]*
(a) small pox (b) tuberculosis (c) malaria (d) cholera

49. The disease of foot and mouth in the animals are caused by— *[RRB TC 2005]*
(a) bacteria (b) fungi (c) protozoa (d) virus

50. Embryo is found in : *[IAS 2002]*
(a) flowers (b) leaves (c) seeds (d) buds

51. The cell wall of algae is made from : *[BPSC (Pre) 2011]*
(a) chitin (b) suberin (c) cellulose (d) cutin

52. Sandalwood tree is considered a
(a) total root parasite
(b) total stem parasite
(c) stem parasite
(d) partial root parasite *[NDA 2011]*

53. The biofertilizer used for the paddy crops is :
(a) Azeto vector species
(b) rizhobium species
(c) fangal root fungal
(d) blue-green algae *[IAS (Pre) 2000]*

54. The unicellular algae used to supply and regulate the oxygen in the space programmes is :
(a) Ulothrix (b) Spirogyra (c) Chlorella (d) Odogonium

55. The appearence of red colour of the red sea is caused by :
(a) moss (b) algae (c) fungi (d) bacteria

56. The branch of botany under which fungi is studied is called :
(a) phycology (b) mycology (c) microbiology (d) embryology

57. The fungi which is appeared on the barks of the plants is :
(a) corticols (b) juphilus (c) sexicoles (d) coprophilus

58. Which one among the following statements about stomach is not correct ?
(a) Stomach acts as a temporary reservoir
(b) Stomach mixes food with gastric juice
(c) Stomach secretes lipase and amylase in gastric juice
(d) Rate of stomach emptying depends on the type of food *[NDA, 2011]*

59. In which of the following chlorophyll does not exist :
(a) algae (b) bryophytes (c) taridophytes (d) fungi

60. The fungi which is used in the preparation of double bread (roti) is :
(a) rizopus stolnifer (b) zygosachhromicez
(c) sachhromicez cerviici (d) sachhromicodis ludecuzai

61. Photosynthesis occurs in :
(a) nucleus (b) mitochondria
(c) chloroplast (d) peroxisome *[BPSC (Pre) 2011]*

62. The ergot is extracted from :
(a) rizhobium (b) calliviseps (c) phytomonas (d) albuego

63. Which of the following is an edible fungi :
(a) mucer (b) pencilleam (c) agaricus (d) rizopus

64. Sexual reproduction causes genetic variation because of :
(a) blending of genes (b) chromosomal changes
(c) shuffling of genes (d) all of the above *[BPSC 2011]*

65. The disease scabies is caused by—
(a) bacteria (b) fungi (c) protozoa (d) nematod *[CDS 2004]*

66. Which one of the following organs breaks fat to produce cholesterol ?
(a) intestine (b) liver
(c) lungs (d) kidneys *[NDA, 2011]*

67. The drug most widely tried against AIDS virus is :
(a) zidovudene (azido thymidine)(b) miconazole
(c) nonoxynol-9 (d) virazole *[JPSC (Pre) 2011]*

68. The disease athelete foot is caused by—
(a) bacteria (b) fungi (c) protozoa (d) nimatod *[IAS (Pre) 2001]*

69. The lichen is formed through the mutual combination of two species of the plants which are :
(a) fungi and fern (b) algae and bryophyta
(c) bacteria and virus (d) fungi and algae *[RRB ASM/GG 2004]*

70. An individual whose blood type is B may in an emergency donate blood to a person whose blood type is ?
(a) B or A (b) AB or A
(c) A or O (d) AB or B *[NDA, 2011]*

71. The lichen is an indicator of :
(a) air pollution (b) water pollution
(c) soil pollution (d) radiation pollution

72. The litmus paper used in the chemical laboratories is made from :
(a) green – algae (b) blue – green algae
(c) lichen (d) fungi

73. Which one among the following statements regarding cell is not correct ?
(a) Shape and size of cells are related to specific function
(b) Some cells have changing shapes
(c) Each cell has its own capacity to perform
(d) Same type of cells are present in all body tissues *[NDA, 2011]*

74. The lichen grown out at the barks of trees is called :
(a) corticoles (b) sexicoles (c) sextiles (d) permalia

75. The lichen grown out at the empty rocks is called :
(a) corticoles (b) sexicoles (c) sextiles (d) permalia

76. Which microorganism causes hepatitis B ?
(a) Virus (b) Protozoa
(c) Bacteria (d) None of the above [JPSC 2011]

77. The medicine of epilepsi is extracted from the lichen :
(a) leconera (b) rosella (c) indocarpon (d) permalia

78. Water percentage in plasma is :
(a) 60% (b) 70% (c) 80% (d) 90%

79. In which of the following rhizoids are found on the behalf of root ? [JPSC (Pre) 2011]
(a) angiosperm (b) gymnosperm
(c) bryophytes (d) pteridophytes

80. Azola is a / an :
(a) bryophyta (b) algae (c) fungi (d) aqeous fern

81. How much protein a working woman must intake everyday ?
(a) 30 g (b) 37 g (c) 40 g (d) 45 g

82. Which of the following has the largest number of chromosomes ? [JPSC (Pre) 2011]
(a) human beings (b) pteridophytes
(c) elephants (d) angiosperm

83. Which of the following animals breathes through the skin ?
(a) Fish (b) Pigeon (c) Frog (d) Cockroach [JPSC (Pre) 2011]

84. Blood is a / an—
(a) connective tissue (b) epithelial tissue
(c) both of the above (d) none of the above [JPSC 2011]

85. In which organ of the human body are the lymphocyte cells formed ?
(a) Liver (b) Long bone (c) Pancreas (d) Spleen [JPSC (Pre) 2011]

86. The coralloid roots are found in :
(a) pine (b) lycopodium (c) cycus (d) dryopteris

87. The largest ovule is :
(a) cocus (b) nitum (c) cycus (d) pynus

88. The chylgoza is extracted from—
(a) cycus (b) pynus (c) cillaginela (d) cicoia

89. The hormone insulin is a :
(a) glycolipid (b) fatty acid (c) peptide (d) sterol [JPSC (Pre) 2011]

90. The medicine ephedrin of asthama and cough is extracted from :
(a) cycus (b) juniperus (c) ephedra (d) pynus

91. The pneumatophores is found in :
(a) betel leaf (b) chestnut (c) jucia (d) maize

92. Which one among the following is not correct about Down's syndrome ?
(a) It is a genetic disorder
(b) Effected individual has early ageing
(c) Effected person has mental retardation
(d) Effected person has furrowed tongue with open mouth *[CDS, 2011]*

93. What is fever ?
(a) Inflammation of skin (b) Inflammation of blood platlets
(c) Pain (d) Inflammation of blood cells
[MPPCS (Pre) 2011]

94. Consider the following :
1. Camphor 2. Chicory 3. Vanilla
In the above codes which of the following is/are plant product ?
(a) Only 1 and 2 (b) Only 3 (c) Only 1 and 3 (d) 1, 2 and 3
[IAS (Pre) 2009]

95. Which part of animal ceel is called powerhouse ?
(a) Cell wall (b) Nucleus
(c) Mitochondria (d) Entire cell *[MPPCS (Pre) 2011]*

96. Which of the following is not found in animal cell ?
(a) Cell wall of cellulose (b) Nucleus
(c) Mitochondria (d) None of these *[MPPCS 2011]*

97. Mammal capable of flying is :
(a) Jaguar (b) Ostrich (c) Pallican (d) Bat
[MPPCS 2011]

98. The edible part of the potato is :
(a) root (b) bud (c) fruit (d) stem

99. The pneumatophores is found in :
(a) hydrila (b) rhizophora (c) water fruit (d) esterkentha

100. Which of the following pairs is wrong :
(a) conical root — onion (b) fusiform root — radish
(c) napiform root — turnip
(d) pneumatophores — mangrove plant

101. Which is the largest mammal ?
(a) Whale (b) African Elephant
(c) Hippopotamus (d) Polar bear *[MPPCS (Pre) 2011]*

102. Who propounded the theory of evolution ?
(a) Spencer (b) Darwin (c) Wallace (d) Huxlay
[MPPCS (Pre) 2011]

103. The ginger is a :
(a) bulb (b) rhizome (c) tuber (d) modified root

104. The onion is a modified form of :
(a) stem (b) root (c) leave (d) fruit

105. Which of the following is a modified stem :
(a) carrot (b) sweet potato (c) coconut (d) potato

106. The edible part of cauliflower is :
(a) fruit (b) bud (c) flower (d) thalamus

107. The longest flower of the world is :
(a) lotus (b) reflesia
(c) a very large cactus (d) None of these *[BPSC (Pre) 1994]*

108. Which of the following plant organ is most vital from its life cycle point of view ?
(a) flower (b) leaf (c) stem (d) root
[BPSC (Pre) 1995]

109. Which one among the following is the largest monkey ?
(a) Spider monkey (b) Baboon
(c) Gorilla (d) Howler monkey *[NDA, 2011]*

110. White blood cells act
(a) as a defence against infection (b) as source of energy
(c) for clotting blood
(d) as a medium for oxygen transport from lung to tissues *[CDS, 2011]*

111. What function does blood perform in body ?
(a) Takes oxygen to all parts (b) Maintains liquidity
(c) Helps in digestion (d) Helps in erection *[MPPCS 2011]*

112. What is the average speed of a bee ?
(a) 10 km/h (b) 5 km/h (c) 1 km/h (d) 16 km/h
[MPPCS (Pre) 2011]

113. What should be the body weight of a 14 years old teenage boy ?
(a) around 12 kg (b) around 14 kg
(c) around 26 kg (d) around 37 kg *[MPPCS 2011]*

114. In which of the following structure the human body vermiform appendix is included :
(a) large intestine (b) small intestine
(c) gall bladder (d) stomach *[IAS (Pre) 2007]*

115. The process of cross pollination is beneficial which causes :
(a) male offspring (b) weak offspring
(c) good offspring (d) seeds

116. The incident of pollination in the closed flowers is called :
(a) clistogamy (b) alogamy (c) autogamy (d) None of these

117. The stigma is always found rough and oily in :
(a) water pollinated flowers (b) insect pollinated flowers
(c) air pollinated flowers (d) almost all types of flower

118. The part of gynoecium which recieves pollen is called :
(a) Stigma (b) Style (c) Ovule (d) Ovary

119. The pollination of snail is called :
(a) zoophilous (b) entomophilous
(c) chiropteriphilous (d) malacophilous

120. Insects that can transmit diseases to human are referred to as
(a) carriers (b) reservoirs
(c) vectors (d) incubators *[CDS, 2011]*

121. If we sprinkle common salt on an earthworm, it dies due to
(a) osmotic shock (b) respiratory failure
(c) closure of pores of skin (d) toxic effect of salt *[CDS, 2011]*

122. Cutting and peeling of onions brings tears to the eyes because of the presence of ?
(a) Sulfur in the cell (b) Aminoacid in the cell
(c) Fat in the cell (d) Carbon in the cell *[CDS, 2011]*

123. Usually stem cutting is a culturing process which is used in :
(a) banana (b) sugarcane (c) mango (d) cotton
[BPSC (Pre) 1994]

124. The anti-malarial drug Quinine is made from a plant. The plant is ?
(a) Neem (b) Eucalyptus (c) Cinnamon (d) Cinchona
[CDS, 2011]

125. The fruits of coconut and mango are :
(a) pome (b) beri (c) drup (d) hesperideum

126. Which of the following is a false fruit ?
(a) apple (b) betel-nut (c) mango (d) cashew (nut)

127. In ripened mango the edible structural part is :
(a) pericarp (b) mesocarp (c) endocarp (d) epicarp

128. The edible part in the coconut is :
(a) pericarp (b) endosperm (c) complete seed (d) blastula

129. How much protein a lactating mother requires in a daily diet ?
(a) 30 gm (b) 20 gm (c) 70 gm (d) 100 gm
[MPPCS (Pre) 2011]

130. The edible part of lichi (a kind of plum) is :
(a) aerial (b) tuberous thalamus
(c) mesocarp (d) seed leaves

131. The edible part of pear is
(a) endocarp (b) seed ferns
(c) aerial (d) pulpythalamus
[RRB ASM 2004]

132. The plant in which seed exists but fruit doesn't is—
(a) sugarcane (b) groundnut (c) almond (d) cycus
[RRB TC/CC 2005]

133. The seeds are developed through—
(a) lady saffron (b) ovule (c) ovary (d) pollen sac

134. The orchid seeds are :
(a) light and dry (b) smaller and sticky
(c) more larger and heavy (d) None of these

135. Which of the following vitamin is used like a hormone :
(a) vitamin A (b) vitamin B (c) vitamin C (d) vitamin D
[Jharkhand PCS (Pre) 2008]

136. The viviparous sproutness is found in :
(a) pine - apple (b) rhizophora
(c) rhizocheonium (d) rhizobium

137. The species through which potato is associated :
(a) soleneci (b) composity (c) gramini (d) crucipheri

138. The botanical name of mango is :
(a) musa sepiantum (b) docus carota
(c) mensiphera indica (d) None of these

139. The crops of oil seeds are associated with :
(a) malvesi (b) crucipheri (c) soleneci (d) composity

140. The peas plant is :
(a) shurb (b) flower (c) bush (d) None of these
[BPSC (Pre) 1994]

141. Development of Goitre (enlarged thyroid gland) is mainly due to deficiency of
(a) Sodium (b) Iodine (c) Calcium (d) Iron
[CDS, 2011]

142. The longest living tree is :
(a) eucalyptus (b) sal (c) teak (d) None of these
[BPSC (Pre) 1995]

143. To suspect HIV / AIDS in a young individual, which one among the following symptoms is mostly associated with ?
(a) Long standing jaundice and chronic liver disease
(b) Severe anemia
(c) Chronic diarrhoea
(d) Severe persistent headache

144. How many chambers are there in heart ?
[CDS, 2011]
(a) 2 (b) 4 (c) 6 (d) 8

145. The saffron is produced through :
[MPPCS 2011]
(a) stamens of hebiscus (b) roots of indgophera
(c) style and stigma of the crocus (d) None of these
[IAS (Pre) 2009]

146. Who discovered peniciline ?
(a) Alexander Graham Bell (b) Alexander Fleming
(c) Christofer Mcdonald (d) Albert Einstein
[MPPCS 2011]

147. The clove is a :
(a) fruit (b) grown bud (c) dryflower bud (d) seed

148. The most stable eco-system is—
(a) Forest (b) Steppe (c) Desert (d) Sea
[RAS/RTS (Pre) 2008]

149. Which of the following factor is the most important for the degradation of bio-diversity ?
(a) self-sustained inheritance (b) control of parasites
(c) devastation of natural habitat (d) insect control
[UPPCS 2010]

150. Which of the following is a man made paddy :
(a) hordium bulgear (b) tritkel
(c) zia mez (d) tritium bulgear

151. Which of the following has maximum protein :
(a) gram (b) pea (c) soabean (d) pigeon pea
[BPSC (Pre) 1995]

152. Which of the following fibres, is not the product of plant stem ?
(a) hemp (b) jute (c) silk (d) cotton
[UPPCS (Pre) 2000]

153. The medicine of malaria (cincona) has been now replaced by an artificial medicine which is :
(a) ampyciline (b) chloroquinine (c) tetracycline (d) chloromycetine
[UPPCS (Pre) 2000]

154. Which one of the following crops supply surplus nitrogen to the soil ?
(a) potato (b) sweet potato (c) sun flower (d) pea
[IAS (Pre.) 1994]

155. Which one of the following vitamins is pronounced by the name of riboflabine :
(a) Vitamin B_1 (b) Vitamin B_2 (c) Vitamin B_6 (d) Vitamin B_{12}
[Jharkhand PCS (Pre) 2008; RRB ASM/GG 2004]

156. The turpentine oil is extracted from :
(a) nettle (b) cycus (c) teak (d) pine
[RRB ASM 2003]

157. The opium is extracted from which part of the plant ?
(a) root (b) stem (c) leaf (d) flower
[RRB TC 2005]

158. Which of the following causes pollution in Tajmahal ?
(a) green house gases (b) ozone
(c) excessive humidity in air (d) acid rain

159. The evaporation process occurs in :
[SSC 2009]
(a) root (b) stem
(c) leaf (d) entire body of the plant
[RRB TC/CC 2003]

160. Which of the following hormones of the human body regulates the calcium and phosphate of the blood ?
(a) Glucogan (b) Growth hormone
(c) Parathyroid hormone (d) Thyroxine
[IAS (Pre) 2007]

161. From where oxygen is made available for photosynthesis of the plants?
(a) air (b) water (c) sunlight (d) soil
[RRB ASM/GG 2004]

162. Which one of the following plants has capacity of nitrogen fixation ?
(a) Paddy and wheat (b) Maize and sugarcane
(c) Gram and other pulsegroup (d) Jute and paddy
[MPPCS (Pre) 2009]

163. Through which one of the following organism mushroom is associated ?
(a) Algae (b) Fern (c) Fungi (d) Lychen
[NDA 2010]

164. The metallic ion found in the chloropyll (chloroplast) is :
(a) iron (b) magnesium (c) zinc (d) cobalt
[BPSC (pre) 2004]

165. Biological catalysts in living organisms are known as
(a) hormones (b) vitamins
(c) steroids (d) enzymes
[NDA, 2010]

166. To which one of the following types of organism do mushrooms belong ?
(a) Algae (b) Ferns (c) Fungi (d) Lichens
[NDA, 2010]

167. The role of chloropyll in photosynthesis is :
(a) to absorb water (b) to absorb sunlight
(c) to absorb CO_2 (d) none of these
[RRB ASM/GG 2004]

[illegible] spinal injury is likely to emerge from ?
(a) gene therapy (b) stem cell therapy
(c) xenograft (d) transfusion

169. Which among the following is not a true fruit ? *[NDA, 2010]*
(a) Apple (b) Date (c) Grape (d) Plum

170. Which one among the following produces seeds but not flowers ? *[NDA, 2010]*
(a) Cashew nut (b) Coffee
(c) Groundnut (d) Pine

171. The common edible mushroom is a *[NDA, 2010]*
(a) mass of fungal spores (b) type of hypha
(c) tightly packed mycelium
(d) structure used for producing asexual spores

172. Xerophytes develope in *[NDA, 2011]*
(a) warm and dry (b) cold and humid
(c) warm and humid (d) cold and dry

173. The last product of glycolisis is : *[NDA 2010]*
(a) glucose (b) pyrubic acid (c) ethyl alcohol (d) CO_2

174. Which of the following is a plant hormone :
(a) adreline (b) insulin (c) secretin (d) oxysin

175. The device used to measure the rate of stem growth is :
(a) hydrometer (b) oxynometer (c) osmometer (d) potometer

176. Which of the following is not needed for the growth of the length of the plant ?
(a) sodium (b) calcium (c) nitrogen (d) phosphorus

177. The disease yellow vein mosaic is associated with : *[RRB ASM/GG 2005]*
(a) apple (b) lady finger (c) sugarcane (d) mustard

178. The food material of the plants is transported to their various organs by— *[RRB ASM/GG 2002]*
(a) xylem (b) cartex (c) phloem (d) pith

179. The water and mineral salts are transported in the plants by—
(a) xylem (b) phloem (c) pith (d) cortex

180. The age of the trees are estimated by :
(a) their weights (b) their heights
(c) their elongation of roots
(d) counting the number of annual rings

[UPPCS (Pre) 2000, BPSC (Pre) 2011]

181. Which one of the following plant is utilized in manufacturing the green fertilizers in India ?
(a) Wheat (b) Jute (c) Cotton (d) Paddy

[CDS 2010]

182. The protoplasm is the physical base of the life; this concept was given by :
(a) Haksle (b) Malipge (c) Robert Hooke (d) Pasteur

183. The theory of mutation was propounded by
(a) Malthus (b) Lamarck (c) Hugo de Vries (d) Haksle

184. The DNA was firstly synthesized by :
(a) Miller (b) Hargobind Korana
(c) Hugo de Vries (d) Kelvin *[BPSC (Pre) 1999]*

185. The word gene was firstly used by :
(a) Waldare (b) Watson (c) Crick (d) Johnson
[RRB ASM/GG 2005]

186. Who called (pronounced) the genetical science as genetics ?
(a) Gregar Mendel (b) C. Corence
(c) H. J. Muller (d) W. Watson *[RRB GG 2002]*

187. The phenomenon of genetic mutation occurs in :
(a) DNA (b) RNA (c) Chromosome (d) ribosome
[RRB TC 2002]

188. The centre for DNA finger print and digonastic is located at :
(a) Hydrabad (b) Banglore (c) New Delhi (d) Chennai
[RRB ASM 2002]

189. When two or more different characters are controlled by a gene then the incident is called :
(a) politene (b) pleotropy (c) polyploidi (d) apomicsis
[IAS (Pre) 2002]

190. Which one of the following is called suicide bag of the cell ?
(a) lysosomes (b) ribosomes (c) nucleosomes (d) golgibody
[RRB ASM/GG 2004]

191. The substance which appears more than 80% in the form of cellular component in the cell is called :
(a) protein (b) fat (c) mineral (d) water
[BPSC (Pre) 1994]

192. The centre of cellular and molecular biology is located at :
(a) Jaipur (b) Lucknow (c) New Delhi (d) Hydrabad
[RRB ASM 2002]

193. The maximum height that a tea plant can attain in nature is :
(a) 5 feet (b) 15 feet
(c) 30 feet (d) more than 40 feet

194. The main work of golgi body is :
(a) respiration (b) to begin cell division
(c) to produce gastric juice (d) secretion *[RRB TC 2005]*

195. Which cellular organelle DNA has ?
(a) centrioles (b) golgi body (c) lysosome (d) mitochondria
[IAS (Pre) 2001]

196. The cellular and molecular control of 'progmmed cell death' is called :
(a) apoptosis (b) aging (c) degenaration (d) necrosis
[IAS (Pre) 2001]

197. Usually on the grass and horticultural leaves water droplets are seen to be appear in the early morning. These water droplets accumulate through—

(a) atmosphere (b) stomata
(c) vascular zone (d) water stomata [CDS 2010]

198. When we consume the goat or sheep beef (muttun); then we are :
(a) primary consumer (b) secondary consumer
(c) tertiary consumer (d) None of these [BPSC (Pre) 1995]

199. The hydrophyte is a/an :
(a) marine animal (b) aqueous plant
(c) plant disease (d) rootless plant

200. Which one of the following plant is Xerophytic ?
(a) mustard (b) peruflower (c) bitter gourd (d) None of these [RRB ASM/GG 2004]

201. Which of the following is an example of abiotic component of the environment :
(a) vegetation (b) animal (c) air (d) All of these [RRB ASM/GG 2004]

202. Hydroponics is associated with a :
(a) plant growth without soil (b) plant growth without water
(c) relation of sound and air
(d) technique of water conservation [RRB ASM/GG 2002]

203. Which one of the following is the largest decomposer of the solar energy ?
(a) bacteria (b) protozoa (c) fungi (d) green plants [SSC Graduate 2005]

204. The epiphytes are those plants which have self sustained growth and development dependent on other plants for their :
(a) food material (b) mechanical help
(c) shadow (d) water

205. Phytotron is a facility, through which :
(a) plants are grown up in the diseaseless circumstances
(b) species of the extinct plants are conserved
(c) plants become available to grow up in the controlled conditions
(d) mutation is affected [IAS (Pre) 1994]

206. A biogeographic region with significant reservoir of biodiversity that is under threat from humans is called as
(a) bioendangered region (b) biodiversity hotspot
(c) biodiversity reservoir
(d) environmentally endangered region [NDA, 2011]

207. The water pollution in the rivers are measured by :
(a) amount of dissolved chlorine (b) amount of dissolved ozone
(c) amount of dissolved nitrogen (d) amount of dissolved oxygen [IAS (Pre) 1998]

208. Which of the following gas doesn't pollute the air ?
(a) CO_2 (b) CO (c) NO_2 (d) SO_2 [RRB TC 2003]

209. The main function of the inner bark of a woody plant is to ?
(a) transport minerals and water from the roots to the leaves

(b) act as a membrane impermeable to water and gas
(c) transport food from the leaves to the other parts of the plant
(d) protect the plant from herbivorous animals

210. Which of the following is not the part of vehicle pollution ? *[NDA. 2011]*
(a) H_2 (b) CO (c) SO_2 (d) N_2O

211. The rate of heartbeat for a normal human body is : *[RRB TC 2005]*
(a) 82 (b) 92 (c) 72 (d) 98

[Uttrakhand PCS (Pre) 2008, SSC CPO (SI) 2009]

212. **Assertion (A) :** Liver of the human body plays a significant role in the digestion of fat.
Reason (R) : Liver produces two significant fat digestive enzymes.
Code :
(a) Both A and B are true and A is correctly explained by R
(b) Both A and B are true but A is not correctly explained by R
(c) A is true but R is false
(d) A is false but R is true

213. Under which branch of science bones are studied ? *[IAS (Pre) 2008]*
(a) Orology (b) Osteology (c) Seremology (d) Geology

214. Which of the following is studied under palentology ?
(a) brain (b) plants (c) primates (d) fossils

215. The study of fishes is called :
(a) Kreptology (b) Sicrotology
(c) Ecuethology (d) Lapideteriology

[RRB ASM/GG 2004]

216. The study of butter-flys is called :
(a) ecuethology (b) neontology
(c) lapideteriology (d) polinology *[RRB ASM/GG 2002]*

217. Which of the following Human organ is affected by the consumption of aflatoxin food adulterent ?
(a) Heart (b) Lungs (c) Kidney (d) Liver

[BPSC (Pre) 2008]

218. Which of the following is studied under Ornithology ?
(a) birds (b) mammals (c) bats (d) fishes

219. Which of the following is studied under Gerentology ?
(a) children (b) women (c) skin disease (d) old ages

220. The branch of Biology under which insects are studied is called :
(a) mamology (b) ornithology (c) entamology (d) ecuethology

221. Alongwith which of the following pidiarties is related ?
(a) Bone disease (b) Heart disease (c) Child disease (d) Eye disease

222. Who propounded the theory of Jumping gene ?
(a) Grager J. Mendel (b) Thoms Hunt
(c) Varvra Macilantak (d) Heneric Hertz

223. Through which of the following disease Adberd Jener is associated :
(a) dysentery (b) intestine fever
(c) small pox (d) paralysis *[CPO, SI 2003]*

224. The scientist who firstly explained about the blood circulation was :
(a) Antoniwan Leeuwenhock (b) William Harbe
(c) John Gregar Mendel (d) Ronald Ros
[CPO, SI 2003]

225. The first heart transplantation was done by :
(a) Dr. William Harbe (b) Sir F.G. Hafkin
(c) Dr. Louis Pasteur (d) Dr. Christen Banard
[MPPCS (Pre) 1994]

226. The structure of DNA was firstly outlined by :
(a) Dr. Meghnath Saha (b) Dr. Stefan Howking
(c) Watson & Crick (d) Dr. Alexander Flemming
[MPPCS (Pre) 1994]

227. The theory of evolution was propounded by :
(a) Louis Pasteur (b) Aristotle
(c) Gregar Mendel (d) Charle's Darwin

228. Jaundice causes the infection in :
(a) Brain (b) Liver (c) Kidney (d) Spleen
[SSC CPO (SI) 2009]

229. Which of the following pair is not correct ?
(a) Josheph Lister — remedial measures of leprosy
(b) Jhons E. Shalk — anti oculation of polio
(c) Alexander Flemming — invention of penicillin
(d) None of these
[RRB ASM 2002]

230. The father of modern antiseptic surgery is :
(a) Josheph Lister (b) Adberd Jener
(c) Louis pasteur (d) William Harbe
[RRB TC 2003]

231. The inoculation of rabbies was invented by :
(a) Adberd Jener (b) Louis Pasteur
(c) Alexander Flemming (d) None of these

232. The principle of Natural selection was given by :
(a) Newton (b) Mendel (c) Darwin (d) Archimedes
[RRB ASM 2002]

233. The word Histology was firstly used by :
(a) Mayer (b) Shliden
(c) Robert Hooke (d) T. H. Maman
[RRB ASM/GG 2005]

234. The thickest human skin is of :
(a) palm (b) sole (c) neck (d) head

235. Which of the following is secreted through lachrymal gland ?
(a) sebum (b) mucous (c) tears (d) sweat

236. The longest cell of the human body is :
(a) cells of the hand (b) cells of the leg
(c) nerve cells (d) None of these

237. The vector of the Japanese encephelytice is :
(a) Bacteria (b) Virus (c) Protozoa (d) Fungi
[UPPCS (Pre) 2008]

238. Which of the following is an example of tissue ?
(a) brain (b) blood (c) liver (d) stomach

239. In living organism biotic catalyst is called ?
(a) Hormone (b) Vitamin (c) Steroid (d) Enzyme
[NDA 2010]

240. The first scientist who synthesized gene (chromosome) in the laboratory—
(a) Mendel (b) Darwin
(c) Watson & Crick (d) Khorana *[BPSC (Pre) 1999]*

241. The principle of 'one gene — one enzyme' was propounded by :
(a) Watson & Crick (b) Hargobind Khorana
(c) Widel & Tatum (d) Margan

242. Which one of the following is necessary for the impulse communication in muscular fibre ?
(a) Calcium (b) Iron (c) Sodium (d) Zinc
[NDA 2010]

243. Who gave Double Helix Model of DNA ?
(a) Dalton (b) Shalk
(c) Watson & Crick (d) Leeuwenhock

244. Which of the following instrument measures blood pressure ?
(a) Spherometer (b) Animometer
(c) Sphygomanometer (d) Ammeter *[BPSC (Pre) 2008]*

245. Which of the following is a sex-linked disease :
(a) leprosy (b) tuberculosis
(c) colour blindness (d) leukemia

246. Colour blindness in the human beings is caused by—
(a) the excess alcoholism (b) defective *X*-chromosomes
(c) defective *Y*-chromosomes (d) the deficiency of vitamin E

247. Which of the following occurs in Haemophilia ?
(a) haemolysis (b) blood doesn't clot
(c) RBC sticks (d) WBC becomes cellular trophic

248. The technique used to detect the paternal character of the offspring is:
(a) protein synthesis (b) chromosome counting
(c) quantitative synthesis of DNA (d) DNA finger printing *[IAS 1997]*

249. Lamarckian theory of organic evolution is usually known as the theory of :
(a) natural selection
(b) inheritance of acquired characters
(c) continuity of germplasm (d) descent with change

250. There is a possibility of contimination in the processed and wrapped food stuffs in the newspaper is of—
(a) Lead (b) Aluminium (c) Iron (d) Magnesium
[NDA 2010]

251. The father of the theory of mutation is :
(a) Mendel (b) Aristole (c) De Vries (d) Darwin

252. Which of the following is not the residual human organs ?
(a) necatating screen
(b) ear drum muscles of the tympanic membrane
(c) fore flattened teeth (d) appendix *[BPSC (Pre) 2004]*

253. The theory of evolution was propounded by :
(a) Haxle (b) Darwin
(c) Lamarck (d) Hugo de Vries *[UPPCS (Pre) 2005]*

254. The metal constituent of chlorophyll is ?
(a) iron (b) potassium
(c) manganese (d) magnesium
[NDA, 2011]

255. The life originates from :
(a) mountains (b) land (c) water (d) air
[BPSC (Pre) 2004]

256. The vitamin which contains cobalt is :
(a) Vitamin B_6 (b) Vitamin B_2 (c) Vitamin B_1 (d) Vitamin B_{12}
[BPSC (Pre) 2008]

257. The locomotional organ of the amoeba is :
(a) Cillia (b) phalasila (c) limb (d) tentecilus

258. Which of the following is known by the name of green protozoa :
(a) Amoeba (b) Uglina (c) Lishmania (d) Paramisheam

259. Which of the following protozoa is known as a connective ring of the plant and animal ?
(a) Amoeba (b) Uglina
(c) Plasomodium (d) Paramisheam

260. In human body a fluid substance namely antamoeba histolitica is found in :
(a) intestine (b) throat (c) stomach (d) lugns

261. The protozoa which causes malaria is :
(a) paramisheam (b) lishmania (c) plasmodium (d) antamoeba

262. The protozoa which causes dysentry (amoebiasis) is :
(a) Amoeba (b) Antamoeba (c) Paramisheam (d) Tripanosoma

263. The protozoa which causes Kala-Azar is :
(a) antamoeba (b) tripanosoma (c) tricomonas (d) lishmania

264. The Sleeping Sickness causes—
(a) tricomonas (b) tripanosoma (c) lishmania (d) plasmodium

265. A unicellular disease resistant parasitic protozoa found in the human intestine is :
(a) E. Colie (b) E. Histolitica
(c) E. Gensivalius (d) Tripanosoma

266. Which one among the following vitamins is necessary for blood clotting ?
(a) Vitamin A (b) Vitamin D (c) Vitamin K (d) Vitamin C
[CDS, 2012]

267. The substance which is used like a gift item in Japan is :
(a) Hylonema (b) Tathya (c) Euplectela (d) Phironima

268. Which of the following is known as Venus Flower of Basket ?
(a) Cycone (b) Uspangia (c) Lecosolinia (d) Euplectela

269. In which of the following blood doesn't exist but respiratory activities are found ?
(a) Cockroach (b) Snail (c) Hydra (d) Kangaroo

270. Which of the following plants can produce allergenic pollen grains :
(a) congress grass (b) fat hen (bathu)
(c) spiny amaranth (d) All of these

271. Which of the following is also called Jelly-Fish ?
(a) Hydra (b) Physelia (c) Orilia (d) Matrideam

272. Which of the following is also known as 'portuguese man of war' ?
(a) Physelia (b) Hydra (c) Orilia (d) Ovilia

273. Which of the following is known as marine animone ?
(a) Hydra (b) Physelia (c) Orilia (d) Obilia

274. Immortality character is found in :
(a) Sponge (b) Hydra (c) Snail (d) Cockroach

275. The disease caused by the asccaris in the human beings is :
(a) tiniosis (b) sleeping sickness
(c) liver rot (d) asccariasis

276. The fossil of Archaeopteryx represents the evidence of origin of
(a) birds from reptiles (b) mammals from reptiles
(c) reptiles from amphibians (d) mammals from birds

[CDS, 2012]

277. How many eyes the snail has ?
(a) 1 (b) 2 (c) so many (d) no any

278. The disease filaria is caused by—
(a) asccaris (b) bucheria benicrofty
(c) plasmodium (d) tinea soleum

279. How snails are benifitial to the farmers ?
(a) by killing or destroying the harmful insects
(b) by killing or destroying the harmful bacterias
(c) both of these
(d) by making empty and porous holes in the soil

280. The ultimate cause of water movement in a plant stem against gravity is
(a) osmosis (b) transpiration
(c) photosynthesis (d) diffusion *[CDS, 2012]*

281. Vermicompost is a / an
(a) inorganic fertilizer (b) toxic substance
(c) organic biofertilizer (d) synthetic fertilizer *[CDS, 2012]*

282. In urine which vitamin is to be found ?
(a) Vitamine A (b) Vitamine B
(c) Vitamine C (d) Vitamine D and K *[CDS 2010]*

283. Which of the following is also known by the name of cuttle fish :
(a) Loligo (b) Cipia (c) Pila (d) Terido

284. Octopus is a :
(a) Jointlimb (b) Soften skin
(c) Hemicordet (d) Soften layer or membrane
[IAS (Pre) 2003]

285. The Devil Fish is the name of :
(a) Pyla (b) Cipia (c) Teridi (d) Octopus

286. The Star Fish is the name of :
(a) Asterias (b) Holothuria (c) Antidon (d) Marine archin

287. The respiration in the fishes are done by—
(a) scales (b) lungs (c) gills (d) nasal cavity

288. The main characteristic of the fishes heart is :
(a) through it only pure blood is passed out
(b) through it only impure blood is passed out
(c) through it both pure and impure types of blood are passed out
(d) in it, there is no blood is to be found

289. The sea horse is an example of :
(a) fishes class (b) mammals class
(c) reptiles class (d) mollusc class

290. Which of the following is a real fish ?
(a) cray fish (b) flying fish (c) cuttle fish (d) silver fish
[UPPCS (Pre) 2004]

291. An artificial kidney works on the principle of :
(a) diffusion (b) osmosis
(c) dialysis (d) active transportation

292. Which one among the following nontoxic gases helps in formation of enzymes which ripen fruit?
(a) Acetylene (b) Ethane
(c) Methane (d) Carbon dioxide [CDS, 2012]

293. The terrestrial species of Echinodermata are :
(a) brittle - star (b) starfish (c) sea-lily (d) None of these

294. The most significant stimulant in the tea leaves is :
(a) brucine (b) caffeine
(c) phenylalanine (d) theine

295. The fishes are assumed to be healthy and more nourishable with comparison to another flesh animals because in the fish :
(a) there exists multi unsaturated acid
(b) there exists saturated fatty acid
(c) there exists necessary vitamins
(d) there exists more carbohydrate and protein [IAS (Pre) 1999]

296. All living organisms are single celled in their earliest history of life. Which of the following is an example of such a cell ?
(a) Ovum (b) Sperm (c) Spermatocyte (d) Zygote

297. The larva of the frog is called :
(a) peupa (b) megot (c) caterpelar (d) tedpol

298. Which of the following is a cold blooded ?
(a) fish (b) frog (c) lizard (d) All of these
[RRB ASM/GG 2004]

299. Which of the following is a despotic animal ?
(a) penguin (b) whale (c) otter (d) tortoise

300. The only snake which forms the nest is—
(a) Chen viper (b) King cobra
(c) Carat (d) Saw Scaled viper [IAS (Pre) 1995]

301. The dinosaurs were :
(a) Cenozoic reptile (b) Mesozoic aves
(c) Paliozoic amphibian (d) Mesozoic reptile

302. The largest living bird is : *[UPPCS (Pre) 2004]*
(a) Kiwi (b) Penguin (c) Ostrich (d) Hawk

303. The smallest living bird is :
(a) Kiwi (b) Huming bird (c) Ostrich (d) Penguin

304. A flightless bird found in the Newzeland is :
(a) Ostrich (b) Alvetras (c) Kiwi (d) None of these
[BPSC (Pre) 1995]

305. The largest flightless bird which can run most fastly is :
(a) Penguin (b) Kiwi (c) Ostrich (d) Amu
[SSC Matric 2001]

306. Ochriopterics is the :
(a) most primitive bird of the jurrasic era :
(b) reptiles of the jurrasic era
(c) reptiles of the triasic era
(d) reptiles of the both jurrasic and triasic era *[BPSC (Pre) 1995]*

307. Where the bird penguin is to be found ?
(a) Africa (b) Latin America
(c) Antarctica (d) North America *[UPPCS 1999]*

308. The Pavo Cristeshs is a scientific name of :
(a) tiger (b) frog (c) man (d) peacock
[RRB CC 2003]

309. The Dolphin is an example of which of the following classes ?
(a) amphibia (b) aves
(c) mammalia (d) pisces *[BPSC (Pre) 1995]*

310. Which of the following is not a mammal ?
(a) fish (b) bat (c) whale (d) None of these
[RRB TC 2003]

311. The largest living mammalia is :
(a) giraffe (b) camel (c) blue whale (d) man
[RRB GG 2003]

312. Which of the following has the smallest living cell ?
(a) bacterium (b) bread mold (c) mycoplasma (d) virus

313. Which one of the following is not bio-degradable ?
(a) Woolen carpet (b) Silver thin foil
(c) Leather bag (d) Jute bag *[CDS 2010]*

314. The heart chambers found in the whale are :
(a) 2 (b) 3 (c) 4 (d) 1
[RRB TC 2003]

315. The total number of bones found in the human body are :
(a) 212 (b) 206 (c) 202 (d) 200

316. How many bones are found in the human skull ?
(a) 8 (b) 30 (c) 32 (d) 34
[BPSC (Pre) 1994]

317. The tissue which plays a significant role in the growth almost all bones is :
(a) areolar tissue (b) cartilage
(c) spongy bone (d) fiboelastic tissue

318. How many pairs of ribs usually coexist in the human body ?
(a) 12 (b) 10 (c) 14 (d) 11
[MPPCS (Pre) 1995]

319. The smallest bone of the human body is :
(a) nail (b) bone of jaw
(c) stepis (d) bone of the nose

320. The longest bone of the human body is :
(a) stepis (b) fibula (c) tibia (d) femur

321. The bones of the leg in the human body are :
(a) hollow (b) humurus (c) solid (d) None of these
[BPSC (Pre) 1994]

322. In which of the following organs of the human body bone tibia is to be found ?
(a) skull (b) leg (c) ankle-bone (d) mouth
[RRB, ASM/GG 2004]

323. The bone of which of the following organ in the human body is the longest ?
(a) spinal cord (b) thigh (c) rib cage (d) ankle-bone
[CPO, SI 2003]

324. The teeth which develop two times in their life cycle of the human beings are—
(a) 4 (b) 12 (c) 20 (d) 28
[BPSC (Pre) 1994]

325. Which one among the following statements is correct ?
(a) All proteins are enzymes (b) All enzymes are proteins
(c) None of the enzymes (d) None of the proteins is enzyme
[CDS, 2012]

326. Which of the following is not a digestive enzyme ?
(a) pepsin (b) renin (c) insulin (d) amelepsin
[CPO, SI 2003]

327. Through which of the following organs maximum nutritional elements in the blood are absorbed ?
(a) mouth (b) large intestine
(c) small intestine (d) abdomen *[RRB, CC 2006]*

328. Which one of the following enzymes is found in the saliva ?
(a) renin (b) tyline (c) tenin (d) resin
[RRB TC 2003]

329. Which one of the following is necessarily needed to digest the food stuffs ?
(a) air (b) water (c) enzyme (d) mineral
[RRB, CC 2003]

330. Turpentine is obtained from :
(a) crude petroleum (b) deodar
(c) pine (d) oak

331. Which of the following acid is present in the human abdomen ?
(a) sulphuric acid (b) hydrochloric acid
(c) nitric acid (d) picric acid
[SSC Mat 2002, RRB, ASM/GG 2004]

332. Consider the following kinds of organisms :
1. Bat 2. Bee 3. Bird
Which of the above is/are pollinating agent/agents ?
(a) 1 and 2 only (b) 2 only
(c) 1 and 3 only (d) 1, 2 and 3
[CSAT, 2012]

333. The millennium Ecosystem Assessment describes the following major categories of ecosystem services-provisioning, supporting, regulating, preserving and cultural Which one of the following is supporting service ?
(a) Production of food and water (b) Control of climate and disease
(c) Nutrient cycling and crop pollination
(d) Maintenance of diversity
[CSAT, 2012]

334. The organ of the human body which collects carbohydrate in the form of glycogen is :
(a) intestine (b) stomach (c) pancreas (d) liver
[SSC Mat 2002]

335. Match the columns I and II

	I		II
1.	epidermis	A.	endothelium
2.	testis tubule	B.	simple columnar epithelium
3.	glomerulus	C.	startified squamous epithelium
4.	pulmonary alveoli	D.	startified cuboidal epithelium
		E.	Simple squamous epithelium

	1	2	3	4
(a)	A	B	C	D
(b)	B	C	D	E
(c)	C	D	A	B
(d)	C	D	A	E

336. The bile is produced through :
(a) liver (b) stomach (c) pancreas (d) receptor
[SSC Mat 2002]

337. The bile is accumulated in :
(a) bile duct (b) receptor (c) liver (d) spleen
[SSC Mat 2003]

338. The bile fluid or pigment which is helpful in fat digestion is actually secreted through :
(a) mucous (b) abdomen (c) pancreas (d) liver

339. Which one among the following nutrients is a structural component of the cell wall of plants ?
(a) Manganese (b) Potassium
(c) Phosphorus (d) Calcium
[NDA, 2012]

340. The function of a pacemaker is :
(a) to regulate the urine formation (b) to regulate digestion
(c) to start heart beat (d) to start respiration
[SSC 1999]

341. Through which of the following organs pressure exerted by the blood (blood pressure) in the human body is realized ?
(a) heart (b) veins (c) arteries (d) cells
[SSC Mat 2002]

342. Which one of the following process is a digestive process which occurs in living organisms ?
(a) decomposition of protein into amino acids
(b) decomposition of glucose into CO_2 and H_2O
(c) transformation of glucose into glycogen
(d) transformation of amino acids into protein
[IAS (Pre) 2010]

343. For a healthy human body the blood pressure (sistolic and dystolic) is :
(a) 120 mm/80 mm (b) 201 mm/110 mm
(c) 90 mm/60 mm (d) 85 mm/55 mm

344. The amount of blood in a healthy human body is :
(a) 10% of the wt. of the human body
(b) 25% of the wt. of the human body
(c) 7% of the wt. of the human body
(d) 5% of the wt. of the human body

345. The average volume of the blood in an adult is :
(a) 3-4 litre (b) 4-5 litre (c) 5-6 litre (d) 6-7 litre

346. Balanced diet should have approximately ?
(a) 1/5 protein, 3/5 fat and 1/5 carbohydrate
(b) 3/5 protein, 1/5 fat and 1/5 carbohydrate
(c) 1/5 protein, 1/5 fat and 3/5 carbohydrate
(d) 1/2 protein, 1/4 fat and 1/4 carbohydrate
[NDA, 2012]

347. While sowing seeds, commonly used fertilizers have :
(a) nitrates (b) potash (c) phosphorus (d) calcium

348. The blood purification takes place in :
(a) lungs (b) heart (c) kidney (d) liver
[RRB, TC/CC 2005]

349. The blood purification process occurring in human body is called :
(a) dialysis (b) heamolysis (c) osmossis (d) paralysis
[BPSC (Pre) 2001]

350. The medicine of epilepsi is extracted from the lichen :
(a) leconera (b) rosella (c) indocarpon (d) permalia
[SSC Matric 1999]

351. In refrigerators, the liquid used as a refrigerant is :
(a) liquid CO_2 (b) liquid N_2
(c) liquid NH_3 (d) super-cooled water

352. Which one among the following statements is correct ?
(a) All arteries carry oxygenated blood
(b) All veins carry oxygenated blood
(c) Except the pulmonary artery, all other arteries carry oxygenated blood
(d) Except the pulmonary vein, all other veins carry oxygenated blood
[NDA, 2012]

353. When we eat something we like, our mouth waters. This is actually not water but fluid secreted from
(a) nasal glands (b) oval epithelium
(c) salivary glands (d) tongue [CDS, 2011]

354. An organ in which RBC forms in the human body is :
(a) heart (b) spleen (c) liver (d) bone marrow [RRB, ASM 2004]

355. What are cold-blooded animals?
(a) Animals with blood without haemoglobin
(b) Animals who are not ferocious
(c) Animals whose body temperature remains constant
(d) Animals whose body temperature varies according to the temperature of atmosphere [NDA, 2012]

356. Who was the inventor of blood groups ?
(a) Landstinear (b) Livine (c) Vinear (d) Leeuwenhock

357. The antigen is a substance which :
(a) decreases the body temperature
(b) destroyes the harmful bacteria
(c) promotes the formation of antibody
(d) uses to protect from the poison [IAS (Pre) 1997]

358. Who detected Rh factor ?
(a) Leeuwenhock (b) Vinear
(c) Landstenear (d) Landstenear & Vinear

359. Sickle-cell anaemia is a disease caused due to the abnormality in
(a) White blood cells (b) Red blood cells
(c) Thrombocytes (d) Blood plasma composition
[NDA, 2012]

360. The blood group AB is called universal recipient because :
(a) antibody is found in the blood
(b) antibody is not found in the blood
(c) blood lacks antigen
(d) blood lacks both antibody and antigen [IAS (Pre) 1995]

361. Carbohydrate are stored in plants and animals in the form of
(a) cellulose and glucose respectively
[✓ (b)] starch and glycogen respectively
(c) starch and glucose respectively
(d) cellulose and glycogen respectively [NDA, 2012]

362. Which one among the following statements regarding heart sounds is correct ?
(a) Heart sounds are caused by the internal blood flow inside the heart
(b) Heart sounds are caused by the external blood flow outside the heart
(c) Heart sounds are caused by opening and closing of heart valves
(d) Normal sounds are called 'murmurs' [NDA, 2011]

363. The seeds can most suitably preserved in :
(a) cold and dry condition (b) cold and wet condition
(c) hot and dry condition (d) hot and wet condition

364. If the blood group of a man and a woman are AB and B respectively then which one of the following blood group is not possible in their offsprings ?
(a) AB (b) B (c) A (d) O *[IAS 1997]*

365. If the blood group of a father and a mother are A and O respectively then which one of the following blood group is not possible in their children?
(a) *B* (b) *AB* (c) *O* (d) *B, AB* or *O*
[IAS (Pre) 1994]

366. The part of the brain in which we feel hunger and satisfaction of the food is :
(a) prosencephalon hemisphere (b) cerebrum
(c) hypothalmus (d) medulla oblongata

367. Ceribrum is associated with :
(a) liver (b) heart (c) brain (d) nerve
[RRB Ahmadabad ASM/GG 2004]

368. The intelligence centre in the human brain is :
(a) cerebellum (b) cerebrum
(c) medulla oblongata (d) None of these

369. The largest part of the human brain is :
(a) brain stem (b) cerebellum
(c) Rhomobencephalon (d) mesencephalon *[RRB CC 2006]*

370. The cells of the human body which have the lowest reconjugation power are :
(a) brain cells (b) nerve cells (c) bone cells (d) liver cells
[SSC Matric 2001]

371. The largest cell of the human body is :
(a) WBC (b) RBC (c) Nerve cell (d) None of these

372. How many nerve pairs coexist in the human's spinal cord ?
(a) 12 (b) 13 (c) 31 (d) 33
[BPSC 2002]

373. The controlling centre of the reflex actions of the human body is located at :
(a) rhomobencephalon (b) cerebellum
(c) medulla oblongata (d) nerve cell *[BPSC (Pre) 2002]*

374. A liverwort is :
(a) a parasite infecting the liver
(b) a long plant without differentiation of root, stem and leaves
(c) a kind of bacterium infecting the liver
(d) a plant of flower shape like the human liver

375. The cell sap is :
(a) a dilute solution of minerals and some organic substances in the vacuole
(b) a dilute solution of minerals in water absorbed by the plant from the soil
(c) exudate from the cell
(d) a solution of different organic substance dissolved in the cytoplasm

[illegible] Certain parts of a plant can be bent easily without breaking. This flexibility in certain parts, like leaf and stem, can be attributed to the abundance of

(a) parenchyma (b) collenchyma

(c) sclerenchyma (d) xylem and phloem *[NDA, 2012]*

[illegible] Prokaryotes are :

(a) animals without well developed nervous system

(b) organisms lacking a definite nucleus

(c) primitive plants without vascular systems

(d) plants that do not produce flowers and fruits

[illegible] Honey which has a high concentration of sugar doesn't decay; because :

(a) it contains a natural anti-oxidant that prevents bacterial attack

(b) bacteria cannot survive in an active state in a solution of high osmotic strength as water is drawn out

(c) bacteria can't survive in an active state as it is totally deprived of oxygen

(d) None of these

379. A herbarium is :

(a) a collection of herbs in dried form

(b) a garden with a collection of medicinal herbs

(c) a garden of various collection of herbs

(d) a centre for the preservation of dried specimen of plants

380. 'Flame of the forest' refers to :

(a) a lady with a flame in her hand found in the forest

(b) a forest full of trees which bursts with red flowers in autmun

(c) a fire always found in some forests

(d) the title of a book

381. Which one among the following cell organelles is semi-permeable ?

(a) Cell membrane (b) Plasma membrane

(c) Cell wall (d) Nucleus *[NDA, 2011]*

382. Which of the following shows a taxonomically closed group ?

(a) earthworm, ringworm, tapeworm

(b) silverfish, cuttlefish, starfish

(c) housefly, dragofly, butterfly

(d) sea horse, sea anemone, sea urchin

383. The phlegm which accumulates in the braonchi is to be cleared during coughing by :

(a) stratified squamous epithelium

(b) stratified columnar ciliated epithelium

(c) pseudostratified columnar ciliated epithelium

(d) simple columnar ciliated epithelium

384. The widely used antibiotic penicillin is produced by :

(a) an algae (b) a bacterium

(c) a fungus (d) none of these

385. Most of the Insects do respiratory activities :

(a) through their skin (b) through their tracheal system

(c) through their lungs (d) through their gills *[IAS 2007]*

386. Which of the following is not a micronutrient for a plant ?
(a) Iron (b) Magnesium
(c) Molybdenum (d) Manganese *[NDA, 2012]*

387. Grey matter consists of :
(a) a large number of neurons
(b) a large number of nerve cell bodies
(c) a large number of nerve fibres
(d) neuroglia

388. Which of the following compounds found in all living organisms are enrich in phosphorus :
(a) carbohydrates (b) fats
(c) nucleic acids (d) proteins

389. Which of the following sugars are components of sugarcane ?
(a) glucose and fructose (b) glucose and galactose
(c) glucose and mannose (d) glucose and ribose

390. Which of the following statements is / are correct?
1. Ligaments are highly flexible.
2. Ligaments connect muscles and bones.
3. Ligaments contain very little matrix.
Select the correct answer using the code given below :
Code :
(a) 1, 2 and 3 (b) 1 and 3 only
(c) 2 and 3 only (d) 1 only *[NDA, 2012]*

391. Enzymes involved in the chemical reactions :
(a) decompose during reactions (b) are used up during reactions
(c) react more rapidly as reactions progress
(d) are not used up during reactions

392. In the milk, fat content is reduced during :
(a) winter (b) summer (c) autumn (d) None of these

393. The colour of cow's milk is slightly yellowish due to the presence of :
(a) xanthophyll (b) riboflavin (c) ribulose (d) carotin

394. Cell membrane is selectively permeable because
(a) it is made up of selected organic molecules
(b) it does not allow transport of some substances from region of higher concentration to the region of lower concentration
(c) the movement of organic molecules occurs only at specific concentration
(d) it allows the movement of certain molecules in and out of the cell while the movement of other molecules is prevented *[NDA, 2012]*

395. Which of the following is the most important for the growth of children up to the age of 14 :
(a) protein (b) vitamin (c) fat (d) milk

396. Roughage, a necessary constituent of the diet consists of largely indigestible :
(a) carbohydrates (cellulose and lignin) and unsaturated fatty acids
(b) carbohydrates such as cellulose and lignin
(c) carbohydrates (cellulose and lignin) and semi-cooked meat
(d) all of these

397. Which of the following is not to be included in the milk teeth of the child of 3rd years age ?
(a) incisors (b) canines (c) molars (d) premolars

398. In termites, the cellulose of wood is digested by :
(a) protozoans (b) bacteria
(c) protozoans and bacteria
(d) cellulose breaking enzyme β amylase

399. One of the digestive juice which lacks enzymes but aids digestion is :
(a) bile (b) succus entericus
(c) chyme (d) chyle

400. Prior to absorption, grape sugar is hydrolysed through an enzyme which is :
(a) lactose (b) maltose (c) sucrose (d) None of these

401. A solution of chlorophyll pigments looks red in the reflected light because of :
(a) diffraction (b) fluorescence (c) reflection (d) refraction

402. Like other body cells, the epithelial cells lining the stomach are protein in nature, yet the epithelial living is not digested by the powerful proteolytic enzyme secreted by the stomach because :
(a) the excess acidity of the gastric juice destroys this enzyme
(b) the mucous secreted by mucosa protects against auto digestion
(c) a rich microflora of bacteria makes the enzyme totally inactive for the autodigestion
(d) both mucous and bacteria give protection against autodigestion

403. Iron which is necessary for the human body is abundantly found in :
(a) egg (b) green vegetables
(c) milk (d) cauliflower

404. Which of the following is the product of a dark reaction of photosynthesis ?
(a) ATP (b) $NADH_2$ (c) $NADPH_2$ (d) Sugar

405. Some animals have a unique method of bringing oxygen directly to the cells; these are :
(a) spiders (b) scorpions (c) insects (d) flatworms

Answers

1. (c)	2. (c)	3. (b)	4. (c)	5. (a)	6. (a)	7. (a)	8. (b)
9. (b)	10. (d)	11. (c)	12. (c)	13. (b)	14. (a)	15. (b)	16. (b)
17. (a)	18. (d)	19. (b)	20. (a)	21. (a)	22. (a)	23. (b)	24. (b)
25. (b)	26. (d)	27. (d)	28. (a)	29. (d)	30. (c)	31. (c)	32. (d)
33. (c)	34. (c)	35. (c)	36. (c)	37. (c)	38. (c)	39. (d)	40. (a)
41. (a)	42. (b)	43. (d)	44. (d)	45. (b)	46. (d)	47. (b)	48. (a)
49. (d)	50. (d)	51. (c)	52. (a)	53. (d)	54. (c)	55. (b)	56. (b)
57. (a)	58. (d)	59. (d)	60. (c)	61. (c)	62. (b)	63. (c)	64. (d)
65. (b)	66. (b)	67. (a)	68. (b)	69. (d)	70. (d)	71. (a)	72. (c)
73. (d)	74. (a)	75. (b)	76. (a)	77. (d)	78. (d)	79. (c)	80. (d)
81. (d)	82. (b)	83. (c)	84. (a)	85. (a)	86. (c)	87. (c)	88. (b)
89. (a)	90. (c)	91. (c)	92. (d)	93. (d)	94. (a)	95. (c)	96. (a)

97. (d) 98. (d) 99. (b) 100. (a) 101. (a) 102. (b) 103. (b) 104. (a)
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